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CHOLESTEROL ABSORPTION IN THE ROACH, *PERIPLANETA AMERICANA*

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(Received 21 August 1976)

The absorption of cholesterol in the alimentary canal of the roach, *Periplaneta americana*, takes place predominantly in the oesophagus and crop followed by the gizzard and gastric caeca. The cholesterol which was esterified in the gut increased gradually in some tissues with increase in time.

INTRODUCTION

Insects are unable to synthesize sterols which are therefore essential components of their diet (CLAYTON, 1964). The sterol requirement of all insects can be met with dietary cholesterol (DADD, 1973). The insects are apparently able to absorb the dietary sterols from their alimentary canal. Detailed studies on the absorption of sterols in mammals are on record (WISEMAN, 1964), but such studies in insects are, however, greatly inadequate. The absorption of cholesterol and other sterols has been investigated in the roach, *Eurycotis floridana* (CLAYTON *et al.*, 1964) where it occurs predominantly in the crop and to some extent in gastric caeca. In the silkworm larvae, *Philosamia cynthia*, the ingested cholesterol is absorbed from the gut wall (CHINO & GILBERT, 1971). However, according to HOUSE (1974), lipids are generally not absorbed in the crop of insects. As the main site of cholesterol absorption in insects is not very clear, studies were undertaken on the cholesterol absorption in *P. americana*.

MATERIALS AND METHODS

Adult male American cockroaches reared and maintained on rat food were used in these experiments. The insects were used within 4 months after the final moult. The experimental insects were starved for 24 hours prior to the test meal. The test meal consisted of a paste of casein and glucose (1:2). Cholesterol (25 μg) and 0.058 μCi cholesterol-4-^{14}C (sp. act. 42.4 mCi/mM) were added dissolved in diethyl ether to the paste and mixed thoroughly. Ether was evaporated completely and the roaches allowed to feed individually. Almost all the test meal was consumed and the roaches were not given any food thereafter. The quantity of the left over food was 1.5 to 5.0 per cent of the diet. At different time intervals hemolymph was collected by cutting the antennae of the roaches and centrifuging them at a low speed. The quantity of haemolymph collected was measured. The roaches were dissected in cold saline and various parts of the alimentary canal were rinsed with cold saline and the unabsorbed food removed and the quantity determined. As the roaches were not fed with any more food, no faeces were obtained during the experimental period. Fat body was also collected. The tissues were extracted for lipids after homogenizing in chloroform : methanol (2:1, v/v) and the non-lipid contaminants washed by the method of FOLCH *et al.* (1957). The purified extracts were evaporated to dryness *in vacuo* and the residues were dissolved in a known volume of chloroform. Separation of lipid classes was achieved by thin layer chromatography using hexane, diethyl ether and acetic acid (90 : 10 : 1, v/v) as the developing solvent system. The spots were visualised by exposure to iodine vapours. The cholesterol and its esters were identified by using appropriate standards. The spots were scraped off and mixed with 10 ml of scintillation fluid (0.5% PPO and 0.05% POPOP in toluene) and the radioactivity determined in a Packard Liquid Scintillation

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TABLE 1. Cholesterol-4-^{14}C incorporation into the tissues of *P. americana* after feeding 25μg cholesterol and 0.058 μCi cholesterol-4-^{14}C per roach.

Time hrs	Cholesterol absorbed mμgm/mg tissue (wet wt.)								% Cholesterol left unabsorbed in intestine
	Oesophagus	Crop	Gizzard	Gastric caeca	Midgut	Hindgut	Fat body	Hemolymph	
1.0	201.9*	255	36.3	4.33	1.8	—	10.0	1.11	19.7
	3.78**	2.55	0.77	0.36	0.07	—	0.16	0.19	
	3.6+	11.2	1.6	0.23	0.1	—	4.9	0.24	
2.0	732	214	197	10.4	2.6	0.8	9.3	0.5	19.8
	7.0	1.6	0.12	0.21	0.2	—	0.03	0.05	
	10.1	17.3	6.2	2.7	0.1	0.1	0.9	0.19	
4.0	443	321	68.0	16.0	7.0	1	14.2	0.9	38.1
	5.2	2.03	0.83	0.23	0.26	0.16	1.2	0.05	
	6.5	13.2	2.8	0.7	0.14	0.1	3.9	0.28	
6.0	580	418	144.6	32.9	9.0	2.46	15.3	8.6	20.2
	9.8	3.86	4.6	0.05	—	0.03	0.91	0.09	
	3.5	17.5	5.2	1.5	0.16	0.08	4.6	1.6	
12.0	93	130	89.9	32.6	15.6	1.4	1.04	0.46	24.1
	26	1.09	0.19	0.34	0.96	0.1	0.09	0.07	
	0.58	6.01	3.6	2.5	0.2	0.09	0.38	0.17	
24.0	60	138.8	29.8	48.7	30.5	1.95	1.79	7.4	14.07
	18.3	1.25	0.37	0.07	0.15	0.03	0.01	0.22	
	0.72	7.1	1.1	2.5	0.8	0.02	0.9	1.65	

* Cholesterol

** Cholestrol ester

\+ Per cent cholesterol absorbed

Spectrometer (Model 3320). The efficiency of counting of individual samples was determined and the appropriate quenching corrections made.

Histochemical studies

The roaches were fed 5mg cholesterol each along with casein and glucose as described above. After 24 hours the various parts of the alimentary canal were dissected out and fixed in neutral formalin for one day and then gelatin blocks made according to the method of BARKA & ANDERSON (1963). The sections were cut at a thickness of 10 μm in a cryostat at -20°C. The sections were dehydrated in the usual manner, stained with Sudan Black B and mounted in glycerine jelly. The control roaches were fed on only casein and glucose and the tissues processed as above.

Ligation of the digestive tract

A ligation was attempted between the crop and the gizzard of the roaches. The method used was essentially the same as described by CLAYTON *et al.* (1964), except that the ligation was between the crop and gizzard in *P. americana*. The insects were given food and water *ad libitum* after the operation until they recovered. They were then starved for one week and given a diet of 20 mg ripe banana with 0.36 μCi of ^{3}H-cholesterol (sp. act. 7 Ci/mM). The ligature was tightened soon after the consumption of the test meal. The roaches were dissected after 24 hours and the radioactivity estimated as described above without separating the cholesterol esters from cholesterol. Any roach showing an improper ligature was discarded. The control roaches were treated in the same manner except that no ligature was involved.

RESULTS AND DISCUSSION

The data presented in Table 1 shows the absorption of cholesterol in different parts of the alimentary canal of *P. americana* at various time intervals after feeding. Of the cholesterol present in the diet only about 21% was absorbed in 1 hour which increased to about 38% in 2 hours. Twelve to 24 hours after feeding only about 14% of the cholesterol was detected in the tissues analysed (Table 1). From the data it appears that most of the cholesterol absorption had taken place by 12 hours after feeding.

The oesophagus and crop were the major sites of cholesterol absorption (Table 1). On the basis of per mg tissue, oesophagus had the highest cholesterol content. However, on the basis of total cholesterol content, the crop showed the maximum. In one hour's time the crop accounted for about 11.2 per cent of the cholesterol in the diet whereas oesophagus contained only 3.6 per cent. This is perhaps obvious as the crop is much larger than the oesophagus. The histochemical studies also showed that crop was the major site of cholesterol absorption in *P. americana* (Fig 1). The crop of the cholesterol fed roaches showed the presence of much more Sudan Black B positive material than the controls. The mid gut showed very little of such Sudan Black B positive material. The additional Sudan Black B positive material in the cholesterol fed roaches was apparently due to the cholesterol absorbed as the lipids including cholesterol are stained by Sudan Black B (BARKA & ANDERSON, 1963). The results of the digestive tract ligation experiments further confirm that the crop is a major site of cholesterol absorption (Table 2). It is seen that even in the roaches with ligation between the crop and the gizzard there was sufficient absorption and cholesterol and its distribution in various tissues even though it was slightly

TABLE 2. Per cent ^{3}H-cholesterol incorporation into the tissues of *P. americana*, with a ligature between the crop and the gizzard, 24 hours after feeding.

	% cholesterol absorbed	
	Control (3)	Roaches with ligature (3)
Crop	55.05	84.3
Gizzard	5.3	4.1
Gastric caeca	23.7	6.3
Midgut	5.0	2.3
Fat body	3.9	1.1
Hemolymph	1.7	1.8

less than the controls. In *Eurycotis floridana* crop was found to be the major site of cholesterol absorption. However, in this study apparently the oesophagus was either not considered at all or was taken along with the crop (CLAYTON *et al.*, 1964). In the larvae of the silkworm, *Philosamia cynthia*, the cholesterol absorption was shown to be in the midgut (CHINO & GILBERT, 1971). According to the earlier work, fats were believed to be absorbed in the crop of the roaches, but later work has shown this not to be true (HOUSE, 1974). It is apparently possible that cholesterol is absorbed in the crop of roaches, whereas other lipids are absorbed elsewhere in the gut.

The gizzard also contained a significant amount of cholestrol. The gastric caeca showed a continuous increase in the cholesterol content whereas in oesophagus, crop and gizzard, first there was an increase in the cholesterol content followed by a decline. Cholesterol was also found in the haemolymph and fat body showing that the absorption has indeed taken place (Table 1).

The predominant form of cholesterol absorbed was unesterified (Table 1). However, with the increase in time after feeding the cholesterol ester increased gradually at least in some tissues. The proportion of free cholesterol to the ester in *P. americana* was about 71:29 (VROMAN *et al.*, 1964). However, in the present studies the free cholesterol was much more than reported in the earlier study. The enzyme, sterol ester hydrolase is very active in the digestive tract of higher animals and is considered to be essential during the absorption of sterols (VAHOUNY & TREADWELL, 1968). In case of insects such enzyme studies have been carried out in the roach, *P. americana* where the cholesterol esterases were found in the homogenates of the various parts of the alimentary canal and which were active in both esterification and hydrolysis of cholesterol and its esters (CASIDA *et al.*, 1957). The cholesterol esterase also occurs in *Galleria mellonella* (CLEMENT & FRISCH, 1946). Recently AGARWAL & NAIR (1976) have studied cholesterol ester hydrolase in the larvae of *Trogoderma granarium* and found that the enzyme specificity is directly correlated with the utilization of various cholesterol esters by this insect. Further, enzyme inhibitors like cholesteryl methyl ether and cholesteryl chloride also inhibit the utilization of various cholesterol esters by this insect. However, the role if any, of these enzymes is not known in cholesterol absorption in insects. Besides, it will be of interest to know what is the major site of cholesterol absorption in different groups of insects.

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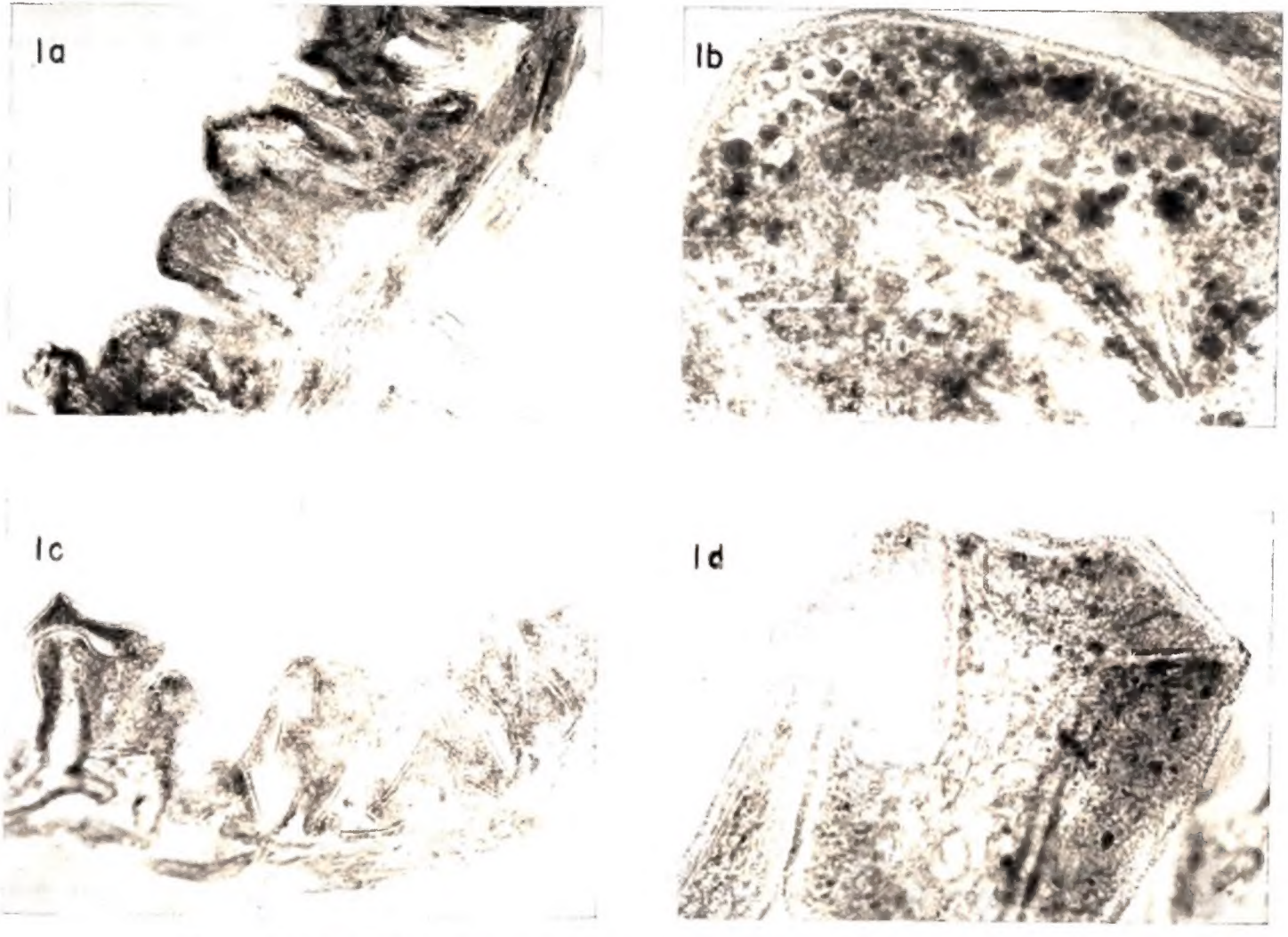

Fig. 1. Photomicrographs showing a part of the cross section of crop of *P. americana* stained with Sudan Black B. (a) Showing Sudan Black B positive material in the crop of roaches fed on cholesterol diet X 100. (b) Same as (a) X 400. (c) Showing Sudan Black B positive material in the crop of control roaches X 100. (d) Same as (c) X 400.

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HISTOLOGICAL AND HISTOCHEMICAL STUDIES ON THE MALE ACCESSORY GLANDS OF CULICINE MOSQUITOES

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The paper deals with studies on the development, histology and histochemistry of the male accessory glands of *Aedes aegypti* and *Culex pipiens fatigans*. The paired accessory glands in both the species grow rapidly from pupal stage till they mature in two-day old adults. The glands have an outer layer of muscles and an inner layer of simple columnar secretory cells. In *Culex* the gland has a central lumen in pupal stage while it is partly filled with cells in *Aedes*. The secretory cells are similar morphologically but secretory activity is more in the posterior part of the glands than in the anterior part in both the species. The secretory granules in *Aedes* are small and are present in the lumen of the gland within polygonal cells whereas in *Culex* they are large and are not in bound form. Histochemical study suggests that the secretion is predominantly proteins, rich in SH-containing amino acids. Further histochemical evidences indicate the presence of glycogen in the secretions of *Aedes* and *Culex*, and mucopolysaccharide in *Culex* only. The relevance of these findings is discussed.

INTRODUCTION

Recent studies have shown that the passage of male accessory gland substance into female mosquito triggers many physiological changes in the female (LEAHY & CRAIG, 1965; CRAIG, 1967; DOWNE, 1975; ADLAKHA & PILLAI, 1975, 1976). The accessory glands in adult male mosquito enlarge prior to mating and diminish in size after mating (LUM, 1961; FOSTER & LEA, 1975). However studies on histology and histochemistry of accessory glands have not received much attention. Only ultrastructure of the male accessory glands of *Culex pipiens pallens* (TONGU *et al.*, 1972) and of the secretory cells in *Aedes aegypti* have been reported so far (DAPPLES *et al.*, 1974). Studies on the chemical nature of the accessory gland secretion are incomplete. In *Ae. aegypti*, the secretion of the gland is reported to be proteinaceous and two proteins have been identified (FUCHS *et al.*, 1969). The present paper deals with a comparative study on the development, histology and histochemistry of the male accessory glands in two species of culicine mosquitoes *viz.* the yellow-fever mosquito, *Ae. aegypti* and the tropical house mosquito, *Culex pipiens fatigans*.

MATERIALS AND METHODS

Mosquitoes for the present study were taken from colonies of Delhi strains of *Ae. aegypti* and *C. p. fatigans* maintained at 28° C and 80% RH in an insectary (ADLAKHA & PILLAI, 1975). Accessory glands from male pupae and adults at different time intervals after emergence were dissected out in *Aedes*-Ringer solution. Size of the gland was measured by means of a calibrated ocular micrometer. For histological studies the glands were fixed in BOUIN'S fluid and processed for paraffin embedding and the sections were stained with either DELAFIELD or HARRIS haematoxylin and Alcoholic eosin. For histochemical study BOUIN'S fixative was used for carbohydrate, CARNOY'S fixative for DNA and RNA and 10% neutral formalin for proteins and lipids. The tissues were either embedded in

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paraffin and processed or they were embedded in gelatin and sectioned in a cryostat. The following histochemical methods have been performed according to the different methods cited in *Histochemistry* (PEARSE, 1968). Proteins were demonstrated by mercury bromophenol blue method, cysteine end cystine by paraldehyde fuchsin method (EWEN, 1962), arginine by SAKAGUCHI reaction, tyrosine by MILLON'S reaction, basic protein by fast green staining at pH 8, 1 2-glycol by PAS method, acid mucopolysaccharides by alcian blue, lipids by sudan black B, neutral lipids by oil red O method, and nucleic acids by methyl green pyronin method and by FEULGEN fast green method.

RESULTS

Morphology

In *Ae. aegypti* and *C. p. fatigans* the accessory glands develop as a pair of bud-like outgrowths from either side of the seminal vesicles in early pupal stage (Figs. 1 & 6). At this stage the glands are translucent and occupy two thirds of the last abdominal segment. In the adult, the glands increase in length and diameter and occupy almost the whole of the last abdominal segment. The glands in both *Culex* and *Aedes* exhibit a progressive increase in size from pupal stage till two days after adult emergence as evidenced by the data presented in Table 1. Two-day old males are mature enough to inseminate the females and normally the males mate only on the third day. The accessory glands in *Aedes* grow more in diameter, the increase being about 67% as compared to increase in length which was only about 30% from pupal to two-day old adults. On the other hand, in *Culex* the glands grow more lengthwise, the increase being about 55% while the diameter increased only about 30% from the pupal stage. The mature glands of *Aedes* are opaque white in colour while in *Culex* they are yellowish. At this stage the glands are fully filled with their secretions.

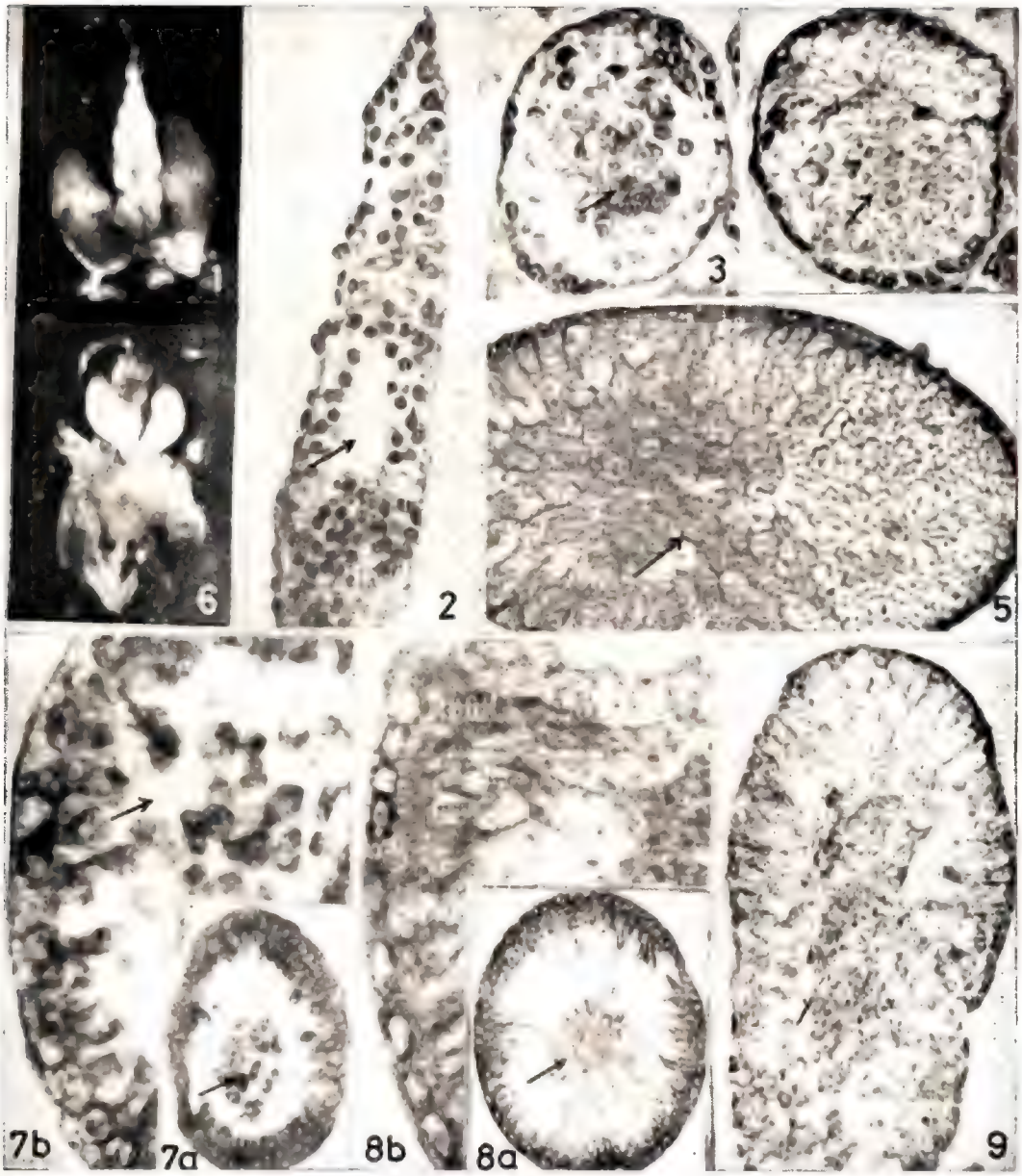
Histology

Accessory glands in both *Aedes* and *Culex* have an outer thin muscular layer and an inner layer of columnar cells. The centre of the gland has a lumen partly filled by secretory cells in the pupa which later on gets completely filled with secretions in the adults. Each secretory cell has a large nucleus with 12 to 14 nucleoli. The secretory cells are absent where the glands join the seminal vesicle. The glands in *Aedes* and *Culex* do not have sperms at any time in them.

In *Aedes* the accessory glands in the pupal stage show loosely packed secretory cells with round nuclei and large intercellular spaces (Figs. 2 & 3). In newly emerged adults the secretory cells enlarge and also increase in number thereby reducing the intercellular spaces (Fig. 4). In the pupal stage the lumen is partly packed with secretory cells and later these cells filled with more secretion and become polygonal in shape. In 1-day males the number of polygonal cells become more and in 2-day

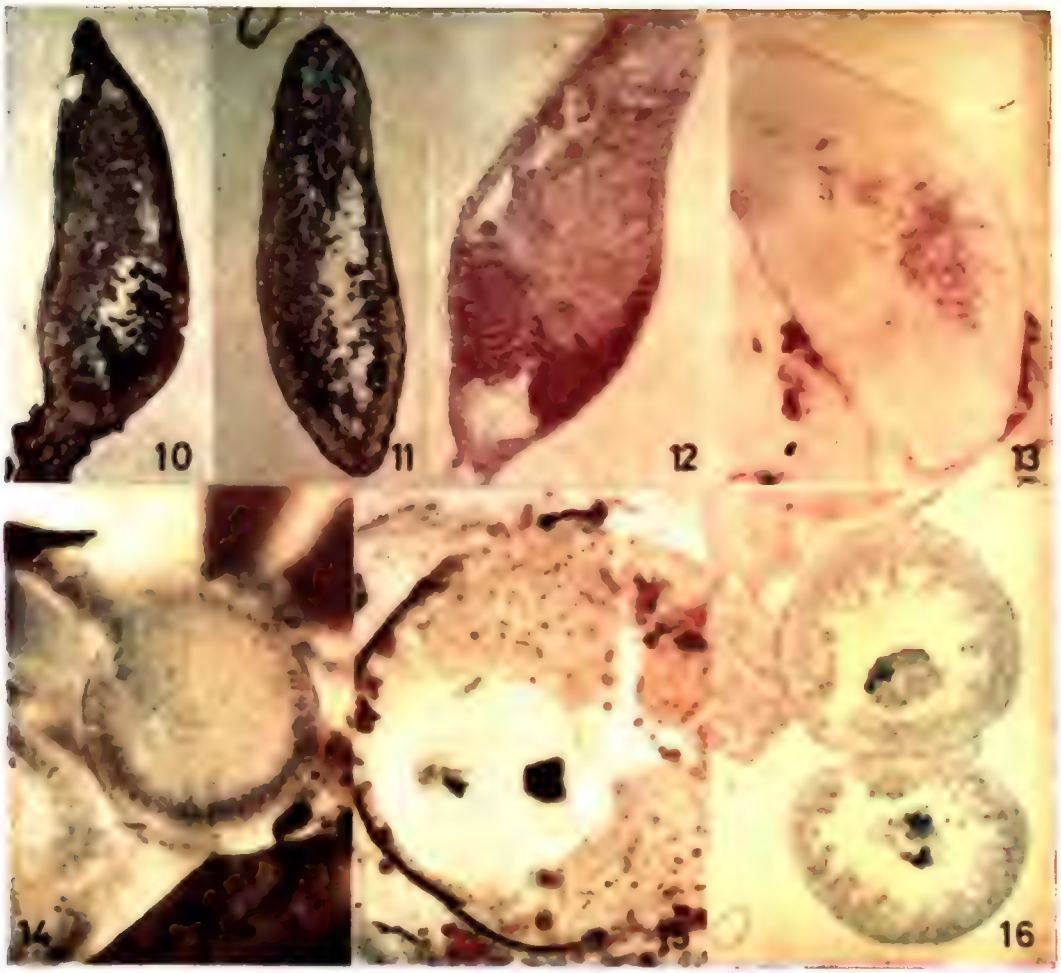
TABLE 1. Measurements of the male accessory glands of *Ae. aegypti* and *C. p. fatigans*

Stage	Length in micron		Diameter in micron	
	Aedes	*Culex*	*Aedes*	*Culex*
Pupa	293.3 ± 16.7	272 ± 12.6	108.3 ± 2.5	132.2 ± 5.8
Newly emerged adult	330.3 ± 10.3	319 ± 6.3	119.2 ± 5.9	137.5 ± 3.3
1 day old adult	374.7 ± 7.4	334 ± 2.7	163.9 ± 6.1	151.8 ± 5.3
2 day old adult	391.7 ± 12.8	492 ± 11.5	177.1 ± 5.0	170.5 ± 9.3



Figs. 1–5. Male accessory glands of *A. aegypti*. Fig. 1. accessory glands of 2–day old adults; Fig. 2. l.s. of the gland of early pupa showing the secretory cells and central lumen; Fig. 3. t. s. of the gland of late pupa showing the central lumen filled with secretory cells; Fig. 4. t. s. of the gland of newly emerged adult and 5. t. s. of the gland of 2-day old adult showing secretory granules in polygonal cells.

Figs. 6–9. Male accessory glands of *C. p. fatigans*. Fig. 6. accessory glands of late pupa; Fig. 7a. t. s. of the gland of late pupa showing central lumen; Fig. 7b. the same enlarged; Fig. 8a. t. s. of the gland of 1 – day old adult showing secretion in the lumen; Fig. 8b. the same enlarged and Fig. 9. t.s. of the gland of 2– day old adult showing the lumen completely filled with secretory granules.



Figs 10-11 L. S. of the gland of *Aedes* and *Culex* respectively showing glycogen (PAS method).

Figs 12-13. L. S. of the gland of *Aedes* and *Culex* respectively showing PAF response (cysteine and cystine bound proteins)

Fig 14 T. S. of the gland of *Aedes* showing lipids (Sudan black B method)

Fig. 15 T. S. of the gland of *Aedes* showing neutral lipids (Oil red 0 method)

Fig 16 T. S. of the gland of *Culex* showing acid mucopolysaccharide (Alcian blue method)

old glands the lumen shows the secretion partly free and partly within the cells (Fig. 5). The secretary granules are small in size.

In the pupal stage of *Culex* the secretory columnar cells are closely packed leaving no intercellular spaces (Figs. 7a, b) and the central lumen of the gland has less secretory cells than in *Aedes*. In 1-day old males the lumen shows presence of free secretory granules which are bigger in size (Figs. 8a, b). The nuclei in the secretory cells are oval in shape. In 2-day old glands the entire lumen is filled with secretory granules (Fig. 9). In mature glands the secretory cells recede to the lining epithelium thereby increasing the space of the lumen.

Histochemistry

The results of the histochemical tests are summarized in Table 2. In the adult *Aedes* posterior region of the gland shows more intense PAS positive response as compared to the anterior region indicating difference in the secretory activiiy of the cells (Fig. 10). In the adult *Culex* the PAS positive granules were confined to the central lumen only (Fig. 11). Acetylation

TABLE 2. Data on the histochemical tests performed on the male accessory glands of *Ae. aegypti* and *C. p. fatigans*

Test performed	Pupa		Adult					
			Newly emerged		1 day old		2 day old	
	Aedes	*Culex*	*Aedes*	*Culex*	*Aedes*	*Culex*	*Aedes*	*Culex*
A. Protein and amino acids								
i) General (bromophenol blue)	*	*	**	*	***	***	****	****
ii) Arginine (SAKAGUCHI oxine reaction)	—	—	—	—	—	—	—	—
iii) Tyrosine (MILLON's reaction)	—	—	—	—	—	—	—	—
iv) Cysteine and Cystine (Paraldehyde fuchsin method)	*	*	**	*	***	***	****	****
B. Carbohydrates								
i) General (Periodic Acid Schiff reaction)	*	*	**	*	***	*	****	**
ii) Acid mucopolysaccharide (alcian blue)	—	—	—	—	—	*	—	*
C. Lipids								
i) General (Sudan-black B)	—	—	Not observed				*	*
ii) Neutral lipids (Oil red O)	—	—	Not observed				*	*
D. Nucleic acids								
i) Methyl green pyronin	***	***	***	***	**	**	*	*
ii) Feulgen fast green	***	***	*	*	*	*	*	*

— No response to tests
* Faint reaction
** Moderate reaction
*** High intensity

with acetic anhydride and pyridine blocks the PAS response. This confirms the presence of neutral polysaccharides in the secretion. Treatment with 1% diastase before PAS treatment showed almost no staining with PAS further confirming that the polysaccharide is glycogen. Presence of acid mucopolysaccharide is tested by alcian blue method. The secretion of mature glands of *Culex* has showed positive response (Fig. 15) but not so of *Aedes*.

Mercury bromophenol blue method shows positive response in pupal and adult accessory glands of both the species. With increase in age the intensity of staining is more in the secretion than in the secretory cells and thus it indicates it is mainly proteinaceous. SAKAGUCHI reaction for arginine and MILLON's reaction for tyrosine are negative in all developing stages of both the species. However, the secretory granules are found to be positive to PAF reaction for cysteine and cystine. In the adult glands the staining is more intense in the posterior region than in the anterior region both in *Aedes* and *Culex* (Figs. 12 & 13). Glands stained with fast green at pH 8.0 show positive response indicating the presence of more of basic amino acids in proteins.

Tests for lipids are performed only in the adult glands. Sudan black B for general lipids is positive in the proximal part of the secretory cells in both the species, though the staining was faint as compared to fat cells. Oil red O staining shows a small amount of neutral lipids detected as small droplets uniformly distributed in the secretory cells of the glands. The staining reaction is not intense as normally seen in the fat cells (Figs. 14 & 15).

Methyl green pyronin staining is positive in the gland. In the pupal stage the cells show mainly bluish green colour of the methyl green but in the adult stage the cells become pinkish due to pyronin staining. These indicate that there is abundant DNA in the secretory cells of the pupal stage and RNA in the secretory cells of the adult stage of both *Aedes* and *Culex*. Control slides hydrolysed by 1 N HCl at 90°C did not take up the stain. These results are further confirmed by FEULGEN fast green method.

DISCUSSION

The present study has revealed that the accessory glands of *Ae. aegypti* and *C. p. fatigans* have an outer circular muscle sheath and an inner layer of simple cells. The development and subsequent increase in size of the glands in mature males are almost identical. The increase in size during post emergence maturation period is due to the accumulation of secretory materials in the gland cells (DAPPLES *et al.*, 1974). Accessory glands of *Aedes* differ from those of *C. p. fatigans* in having small central lumen. In *C. p. pallens* (TONGU *et al.*, 1972) the glands have narrow canals in the centre in place of lumen. The cells of the glands are all morphologically identical and are found to be secretory. Ultrastructural studies have shown that the cells of the accessory glands in *Ae. aegypti* are morphologically similar (DAPPLES *et al.*, 1974) unlike in *C. p. pallens* wherein there are four types of morphologically different secretory cells in the accessory glands (TONGU *et al.*, 1972).

In *Ae. aegypti* the secretion of the mature glands is bound in polygonal cells. This is supported by the findings of DAPPLES *et al.* (1974) as they have suggested that the secretion is apocrine in *Ae. aegypti* and that the secretion-laden cells are pinched off forming membrane bound packets of secretory granules and other cytoplasmic components and that the loose cytoplasmic material is also released during the apocrine process and before the cell membranes are

reformed. However, in *C. p. fatigans* the secretion is not in bound form. In *C. p. pallens* three types of secretory granules have been observed; of these only one type is found to be free and the other two types are bound in membranes (TONGU *et al.*, 1972). Whether the release of secretion in *C. p. fatigans* is holocrine or apocrine is not clear from the present study. The glands in both the species are devoid of secretory granules in their pupal stage. The secretory granules of *Aedes* seem to be finely granular and in bound form while in *Culex* they are bigger and not in bound form.

In both the species the secretory cells of the posterior region are shown to be more active with regard to PAS staining and PAF stairing suggesting the existence of two types of secretory cells. Electron microscopic studies of the glands of *Ae. aegypti* have revealed only two types of secretory cells, the anterior cells being less active than the posterior ones (DAPPLES *et al.*, 1974). Histochemical studies on nucleic acids reveal that the DNA content was more in early stages of the development of gland and later more RNA could be seen in cells near the centre. This evidently coincides with the biosynthesis of secretory substances in the cells of the glands. The present study indicates that the secretions in both the glands are predominantly protemaceous. The accessory gland substance of *Ae. aegypti* known as matrone (CRAIG, 1967) consists of two protein fractions. Of these only one fraction stimulates oviposition, but both together ensure monogamy in females (FUCHS *et al.*, 1969; FUCHS & HISS, 1970, HISS & FUCHS, 1972). The accessory gland secretion of *Aedes* and *Culex* is found to be rich in SH-containing amino acids. Similarly in *C. p. pallens* the secretion of the gland is stainable with aldehyde fuchsin and the authors have suggested a probable hormonal function for the accessory glands (TONGU *et al.*, 1972).

The presence of the polysaccharide glycogn in adult gland suggets that the secretion may be a glycoprotein. Earlier biochemical evidence in *Ae. aegypti* indicates that the main constituents of matrone may be glycoproteins or a protein and a polysaccharide (FUCHS *et al.*, 1969). The secretion of the accessory glands of *Culex* shows the presence of acid mucopolysaccharides though its significance is not clear. Recent studies have shown that the accessory gland substance is involved in blood intake and blood digestion of the female mosquitoes (ADLAKHA & PILLAI, 1976; DOWNE, 1975) and it is also essential for the fertility of the eggs (ADLAKHA & PILLAI 1975). The multifarious functions of glands do suggest the possibility of many chemical components in their secretion.

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TRANSMISSION STUDIES OF WATERMELON MOSAIC VIRUS BY APHIDS

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Comparative efficiency of four species of aphids as vectors of watermelon mosaic virus revealed *Aphis gossypii* as most efficient vector. *Lipaphis pseudobrassicae* and *Aphis nerii* are reported as additional vectors of watermelon mosaic virus. A detailed study of virus–vector relationship was made using *Aphis gossypii*. Transmission of the virus was apparently non–persistent.

INTRODUCTION

Watermelon mosaic virus is more prevalent than any other cucurbit viruses in areas of Eastern Uttar–Pradesh. It infects several cucurbits and causes a heavy loss by reducing the quantity and quality of its fruits. BHARGAVA & TEWARI (1970) and BHARGAVA *et al.* (1975) found that watermelon mosaic virus perpetuates on a number of cucurbits throughout the year and the vectors *Myzus persicae* and *Aphis gossypii* play an important role in its transmission in nature. RAZVI & KHURANA (1968) found that *Aphis gossypii* constitutes a major component of the vector population in Gorakhpur. In the present investigation detailed studies were undertaken to find out the virus–vector relationships of watermelon mosaic virus with its most efficient vector *Aphis gossypii*.

MATERIALS AND METHODS

All the experiments were carried out in an insect–proof chamber which was regularly fumigated to keep it free from insects. Cultures of watermelon moasic virus originally collected by BHARGAVA & TEWARI (1960) was maintained on *Cucurbita pepo* L. Var. *caserta* plant by mechanical inoculation. Test plants *Cucurbita pepo* L. Var. *caserta* were grown in 22 5 cm earthen-pots. The condition of insect and the methods of culturing and handling of the insects were the same as those described by WATSON & ROBERTS (1939). The test aphids were collected from various host plants in the field and placed in a collecting cage until used. The insects were transferred from collecting cages to 15 cm petri dishes by means of a camel hair brush. Only full grown apterous aphids were used. Unless otherwise stated the aphids were given four hours preacquisition fasting, two minutes acquisition feeding and twenty four hours infection feeding time. Five infective aphids were used in each test. During the acquisition feeding insects were watched through a magnifying lens to see when they took up a feeding position and the time was recorded from them. At the time of post acquisition feeding the test plants were covered with glass chimneys. These insects were killed at the end of experiments by spraying 3% Folidol E 605 solution. The plants were kept for one month under observation. The symptoms of infection produced by infective aphids appeared after 10 to 12 days.

RESULTS

Comparative efficiency of four vectors to transmit watermelon mosaic virus

Results in Table 1 indicate that of four aphids tested, *Aphis gossypii* is more efficient vector of watermelon mosaic virus which is followed by *Myzus persicae*, *Lipaphis pseudobrassicae* and *Aphis nerii*. Therefore, *Aphis gossypii* was selected for detailed examination of virus – vector relationships.

TABLE 1. Comparative efficiency of four aphids as vectors of watermelon mosaic virus

Aphid vector	Host plant	Number of plants infected out of 30	Percentage of infection
Aphis gossypii	*Lagenaria vulgaris* SCHARD.	26	86. 6
Myzus persicae	*Raphanus sativus* L.	24	80. 00
Lipaphis pseudo-brassicae	*Brassica compestris* L.	18	60. 00
Aphis nerii	*Calotropis procers* L.	15	50. 00

Virus–vector relationships of watermelon mosaic virus and Aphis gossypii

1. *Effect of preliminary fasting on the transmission*

Results in Table 2 indicate that aphids can acquire the virus even without preliminary fasting but the efficieney increased when they were given a fast upto four hours. This, however, decreased when the preliminary fasting period was increased.

TABLE 2. Effect of preliminary fasting on transmission

Preliminary fasting time (hours)	Number of plants infected out of 15 treated	Percentage of infection
0	4	26.6
2	6	40.0
4	8	53.3
6	5	33.3

2. *Influence of number of aphids on the infection*

Results obtained (Table 3) showed that a single aphid was capable of transmitting the virus, although percentage of transmission was very low. The optimum percentage of transmission was obtained with a group of five aphids.

TABLE 3. Infection transmitted by different number of aphids

Number of aphids transferred / plant	Plants infected out of 15 treated	Percentage nfection
1	5	33.33
5	10	66.6
10	9	60.0
15	9	60.0

3. *Effect of acquisition feeding time on transmission*

Results in Table 4 show that the optimum acquisition feeding time is 2 minutes. This also shows that with higher acquisition feeding time, there was a corresponding decrease in the incidence of virus transmission.

TABLE 4. Infection transmitted by the aphid with varying acquisition feeding time

Acquisition feeding time	Number of plants infected out of 15 treated	Percentage of infection
30 seconds	2	13.33
1 minute	8	53.3
2 ,,	10	66.6
5 ,,	8	53.3
10 ,,	5	33.3
15 ,,	5	33.3

4. *Effect of infection feeding time on transmission*

The result in Table 5 indicate that maximum percentage can be obtained at 24 hours infection feeding time.

TABLE 5. Effect of infection feeding time on transmission

Infection feeding time	Number of plants infected out of 15 treated	Percentage infection
2	5	33.3
12	7	46.6
24	10	66.6
48	8	53.3

5. *Effect of postacquisition fasting on infection*

Results (Table 6) show that the maximum infection occurred when the aphids were not starved after acquisition feeding. It decreased with increase in starvation period and the infection was completely lost after one hour.

TABLE 6. Effect of post acquisition fasting on infection

Postacquisition fasting time	Plant infected out of 15 treated	Percentage of infection
0 minute	10	66.6
5 ,,	8	53.3
15 ,,	4	26.6
30 ,,	2	13.3
60 ,,	0	0
2 hours	0	0

6. *Effect of transferring an aphid to a series of healthy test plants after acquisition feeding*

An experiment was carried out to find out the extent of plants to which an individual viruliferous aphid could infect after acquisition feeding. Results (Table 7) show that first three aphids caused infection to first plant and the 1st and 3rd aphid could also infect second plant but not the third.

TABLE 7. Number of successive plants infected by each aphid

Number of plants	Aphids				
	1	2	3	4	5
1st	+	+	+	—	—
2nd	+	—	+	—	—
3rd	—	—	—	—	—
4th	—	—	—	—	—
5th	—	—	—	—	—

DISCUSSION

Observations made in this study show that all the four aphid vectors transmitted the virus. This also shows the comparative efficiency of these four aphids as vectors and *Aphis gossypii* has been found as most efficient vector of watermelon mosaic virus. Observations made by earlier workers have indicated *Myzus persicae* to be the most efficient vector of watermelon mosaic virus (CAUDRIET, 1962; TOBA, 1963). The ability of an aphid species to transmit the same virus in different areas is affected by the aphid's physiological specialization and vector specificity of the virus isolates (ROCHOW, 1960). In the present investigation too, *Myzus persicae* and *Aphis gossypii* are important vectors, but *Aphis gossypii* is comparatively more efficient to transmit the virus than *Myzus persicae*. The efficiency of this vector is also suggested by findings of BHARGAVA *et al.* (1975) who found *Aphis gossypii* constituting the major component of vector population in areas of Eastern Uttar-Pradesh.

The aphids *Lipaphis pseudobrassicae* and *Aphis nerri* are being reported for the first time as vectors of watermelon mosaic virus.

Studies on virus-vector relationships of watermelon mosaic virus and *Aphis gossypii* show that a single aphid can transmit the virus although, the optimum percentage of infection was obtained by a group of 5 aphids.

Preacquisition fasting up to 4 hours increases the efficiency of vector to virus uptake though transmission was obtained even without fasting. The maximum acquisition of virus was obtained in two minutes, subsequently becoming reduced. These findings support the views (BRADLEY, 1952) that in the acquisition of nonpersistent viruses, primary or initial probes within 10 seconds to 1 minute are important. The preliminary fasting time given to *Aphis gossypii* increased the efficiency of the aphids

only when short feeding periods were given. Similar observations have been made by BHARGAVA (1951) and MILLER (1952). After 1 hour of post acquisition fasting the aphids failed to transmit the virus. The decrease in the capacity to produce infection with an increase of post-acquisition fasting period is characteristic property of non-persistent virus (WATSON & ROBERTS, 1939). The vector virus relationships under study shows that the virus is non-persistent in nature. This is further proved by serial transfers of aphid to healthy plants where the aphid ceases to be infective very soon while feeding on a series of test plants.

The prevalence of this aphid on wild and cultivated cucurbits and non-persistent nature of the virus are responsible factors for wide occurrence of this disease in areas of Eastern Uttar-Pradesh.

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OBSERVATIONS ON THE BIOLOGY AND BEHAVIOUR OF *CERATOSOLEN MARCHALI* MAYR (AGAONIDAE, CHALCIDOIDEA, HYMENOPTERA)

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Ceratosolen marchali Mayr breeds in the gall figs of *Ficus hispida* L. The females of this species are responsible for cross pollination in this *Ficus*. *C. marchali* is protandrous and the males are apterous, vermiform and short-lived. Observations on certain aspects of the biology and behaviour of *C. marchali* are given and discussed. Brief accounts of the morphology of the egg, larval and pupal stages are also given. Six distinct generations of the wasps are traced in a year. The sex ratios show variation during different generations. The probable reason for this is discussed.

INTRODUCTION

Ceratosolen marchali MAYR was reported from India by JOSEPH (1953) among the fig wasps emerged from *Ficus hispida* L. from Kottayam, Kerala. WIEBES (1963) reported the species from various countries including Ceylon, India, China, Malaya and Queensland. Earlier, MAYR (1906) had described the species from Java and GRANDI (1928) had redescribed the same species from his collections of fig wasps.

The females of *C. marchali* MAYR (Fig. 1A) are 1.4 to 1.5 mm in length; dorsum of their head, thorax and abdomen mostly brownish-black; antennal segments four to eleven smoky-brown; remaining parts of the body with pale brownish yellow colouration. Wings are hyaline and closely pubescent. The males (Fig. 1B) which are between 1.1 mm and 1.3 mm in length are uniformly pale yellowish-brown. As in the males of other genera of fig wasps, they lack wings

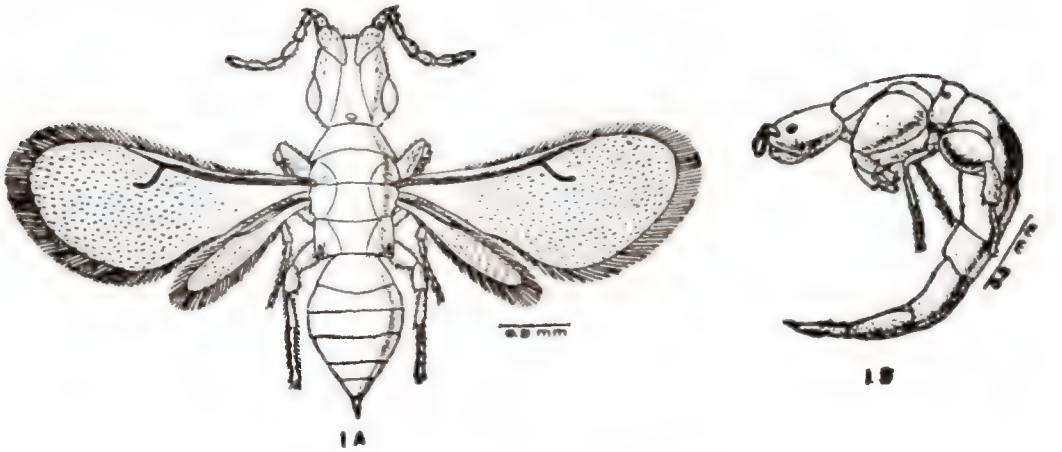


Fig. 1. *Ceratosolen marchali* MAYR–Adults
A : Female (dorsal view) ; B : Male (lateral view).

and the abdomen is tucked under the rest of the body.

Certain aspects of the biology and behaviour of this species of insect that breeds in the receptacles of *Ficus hispida*, are dealt with in this paper.

MATERIAL AND METHODS

Ficus hispida trees, commonly available in Calicut where the work was undertaken, are dioecious bearing seed flowers and gall flowers on separate trees. Seed flowers have long-styled ovaries and gall flowers have short-styled ones; the fig wasps develop only in the latter type of ovaries. Regular collection of gall figs containing insects in different stages of development were made and were brought to the laboratory to study their breeding biology and the behaviour of the adults. Galls (modified ovaries) of the figs were dissected out to remove the egg, larval and pupal stages for study.

Rearing of the larval and pupal stages of the fig insects and breeding them in the laboratory is not possible, as the insects can survive only inside the fig ovaries. However, rearing of the adults was attempted after their eclosion in the laboratory. The females fed on diluted honey were utilized for the study of their oviposition behaviour and longevity.

In nature, the development of the figs of *Ficus hispida* was followed from the time of their appearance till maturity to estimate the duration of one life cycle and to calculate the number of generations completed in a year. Field observations also were made on penetration of the female wasps into the young syconium, the nature and time of eclosion of the adults and the behaviour of the female adults before flying off in search of tender figs.

OBSERVATIONS AND DISCUSSION

1. Emergence, copulation and eclosion

The protandrous males come out of their galls by making exit holes by means of their mandibles. Soon after emergence, they are busily engaged in searching, locating and opening the galls containing the females of their own species. Normally they do not fail to identify the galls containing their own females. On locating one such gall, the male makes a small opening on it by means of its mandibles and then introduces the terminal extensile sigments of its abdomen into the gall, holding on to the fig gall firmly with its legs. In this way while the females are still inside their galls, the males fertilize them. During this process, most of the males are found to introduce their heads slightly into the gall. This probably enables the male insect to keep in sensory contact with the female by means of their antennae. The act of copulation is also accomplished by waves of contractions originating at the base and passing towards the terminal part of the abdomen. The abdomen is withdrawn from the gall after copulation. Each male often mates with 4 or 5 females in succession. After the females are fertilized, the males help them in emerging out of the galls.

In nature, the eclosion, i. e. the exit of females in large numbers out of the syconium through the ostiolar opening, usually takes place initially during the early part of the morning and later irregularly during the day time. Since the females are highly phototaxic, those that emerge during the night remain inside till the next morning. The duration of eclosion from a single syconium may last from three to four days. Prior to eclosion, the figs will be sufficiently swollen and their ostiolar opening becomes enlarged. For a given tree for the completion of eclosion it normally takes about seven to ten days. In a given locality the maturity of the figs and eclosion of the insects in different trees are spread out for a duration of one and a half months.

2. Sex ratio

The sex-ratio of the individuals emerging from *Ficus* receptacles was not uniform. When the sex-ratios from different receptacles belonging to the 6 generations of a year were calculated, an average ratio of 38 males for 100 females was obtained.

3. Post-emergence behaviour and oviposition

After emergence, the females of *C. marchali* remain inside the syconium for some time. The males which do not normally go out of the syconium die inside it.

After exit, the females remain for a short time on the surface of the fig to clean their body and wings with the help of their legs. The fore and hind tibiae provided with specialized setae and spines are used in the cleaning work. By the time the wasps eclose from one crop of ripe figs, the next crop of tender figs in the same tree will have reached a suitable stage to receive the eggs of *Ceratosolen* females. The females walk over the surface of the tender figs, their antennae feeling the surface till they locate the site of the ostiolar opening, which at this stage is blocked by the ostiolar bracts. They then struggle to enter inside the fig through the ostiole. The general shape of the head and body, the strongly built fore tibiae and tarsi as well as mandibular appendages (having serrated ridges) help them in forcing their way into the interior of the figs. During this strenuous effort, the females get mutilated, generally losing their wings and parts of their antennae. This task of penetration into the cavity of the fig generally takes 5 to 10 minutes.

The females after locating the ovaries inside the receptacle start oviposition. They lay one egg in each ovary. The ovipositor which is kept horizontally inside its sheaths, is taken out and lowered. The abdomen is raised. In this position, the ovipositor will be vertical to the axis of the body and the tip of the ovipositor is introduced into the style of the ovary. Slowly the abdomen is lowered so that the ovipositor can penetrate into the style and into the region of the ovule, where the egg is deposited. The egg proper comes to be deposited between the nucellus and the ovarian wall, with its peduncle attached to the latter. A single female lays about hundred eggs in as many ovaries at a stretch. Along with the deposition of the egg, the insect also injects a certain amount of poison from its well developed poison gland into each ovary. Such secretion of *Blastophaga psenes* has been found to induce the parthenogenetic development of the endosperm of the *Ficus* ovary, thereby creating a suitable *milieu* for the growth of the insect embryo (LONGO, 1909; GRANDI, 1929).

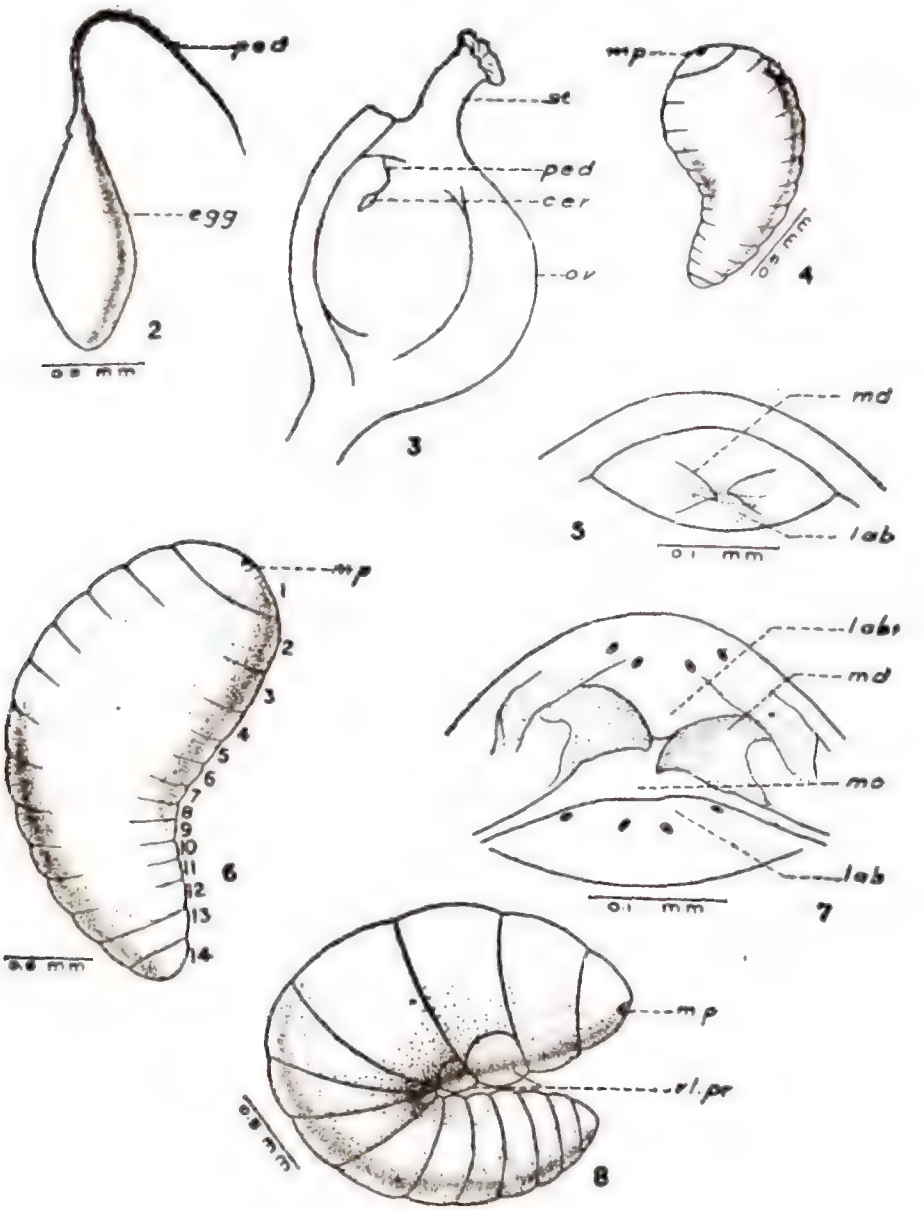
The females of *C. marchali* are found to penetrate the syconium of the seed figs also, by mistake. These females that emerged out of the ripe fig carry pollen grains on their body and when they reach the female flowers and attempt to oviposit, the transfer of the pollen is effected. In several instances 10 to 15 dead females of *Ceratosolen* were observed inside such receptacles.

4. Longevity

Adult male and female *C. marchali* have a short life span. The males normally do not come out of the interior of the fig. After their emergence they survive only for 20 to 28 hours. The females live longer, but most of them die within 24 to 30 hours. However, a few were observed to live for a second day, thus having about 48 hours of maximum longevity.

5. The egg, larval and pupal stages

The egg is almost oval, with its two ends distinctly blunt (Fig. 2). One end of the egg is produced into a conical projection, which is connected to a long stalk, the peduncle. Inside *Ficus* ovary the eggs are laid nearer the base of style (Fig. 3). Incubation period of the egg lasts for 5 or 6 days. The larva that hatches out (Fig. 4) is transparent and has almost the shape of the egg. Segmentation and mouthparts



Figs. 2–8. *C. marchali* egg, larval and pre-pupal stages. 2: Egg; 3: Location of the egg inside the *Ficus* ovary; 4: First stage larva; 5: Mouthparts of the first stage larva; 6: Second stage larva; 7: Mouthparts of the second stage larva; 8: Pre-gupa.

cer: the egg; lab: labium; labr: labrum; md:mandible; mo: mouth; mp: mouthparts; ov: ovary; ped: peduncle; st: style; vl. pr: Ventrolateral prominences.

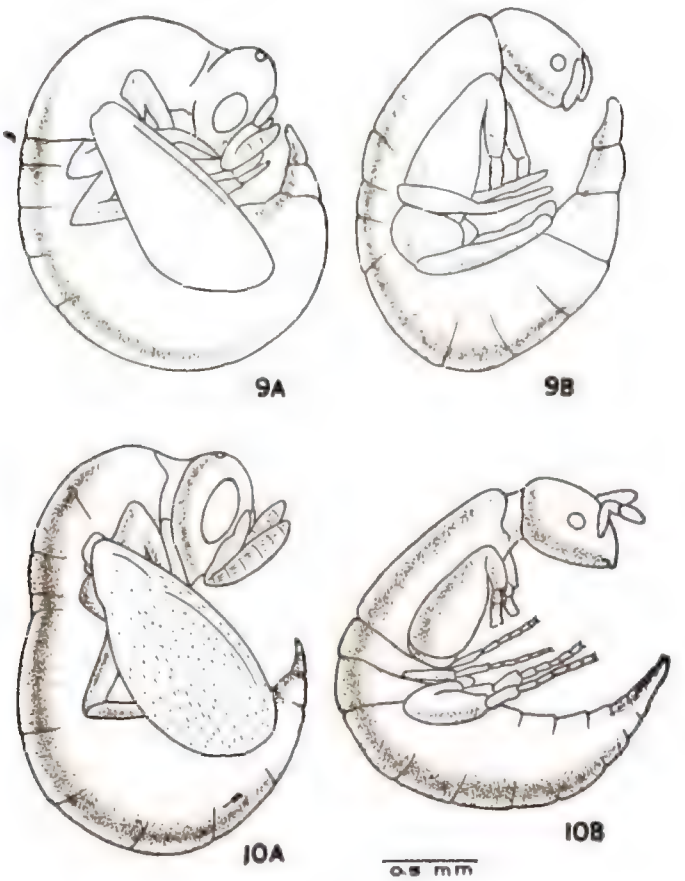
(Fig. 5) are indistinct. In about six days this transforms into the second stage larva (Fig. 6) which is distinctly segmented. The larva actively feeds on the food available inside *Ficus* ovary and grows in size. The mouthparts develop further (Fig. 7). The mandibles get further sclerotized.

After attaining its maximum size, the first four segments of the larva become enlarged. This is the prepupa (Fig. 8) which now shows a definite constriction at the region of the junction of the thorax with the abdomen. It enters the pupal stage within 8 to 10 days.

During the initial phase, the pupa (Figs. 9A & B) is whitish in colour, as the integument is not chitinized. The cuticle gets chitinized within five to six days and the pupa is then named 'brown pupa' (Figs. 10A & B). The final moult of the pupa gives rise to the adult that emerges out of its gall within a short time.

6. Number of generations in a year

The development, growth and maturity of the fig wasps of each generation occur simultaneously with the growth and maturity of the fig. In two trees of *Ficus hispida*,



Figs. 9–10. *C. marchali* pupal stages
9A : White pupa (Female) ; 9B : White pupa (Male) ;
10A: Black pupa (Female) ; 10B: Black pupa (Male).

six distinct eclosions of adults took place, one each in January, March, May, July, August and November, during the year 1966. Each generation of the wasps takes 50–60 days for completing the development from egg to adult stage.

On the emergence of *Blastophaga psenes* and *Philotrypesis caricae*, GRANDI (1929) and JOSEPH (1958) stated that the males of these forms attain maturity and come out of their galls by making exit holes themselves. This protandrous condition and the help the males render the females to come out of their galls, seen in *C. marchali* also, may be widespread and common in the Agaonids. Moreover in this family, as a rule, the females are fertilized while they are still inside their galls before their emergence.

The differences in the timing of eclosions permit the availability of the adult insects almost throughout the year. However, on the same tree when once eclosion has started it may last for a period of 7 to 10 days. This period is shorter than that required for the eclosion of insects from *Ficus carica*, which lasts for a total period of three weeks for a given tree. The shorter period of eclosion may be due to the fact that the wasps from *Ficus hispida* are able to complete their development in a shorter period synchronising with the maturity of the fig syconia in which they develop.

The average sex ratio of the males to the females of *C. marchali* eclosed in six different generations ranged from 30 to 40 males for 100 females. The higher proportion of the females could be due to the fact that in them the females are fertilized while they are inside the gall itself and hence their chances of emergence without fertilization are less. It is natural that a uniform sex–ratio is not obtainable due to the varying rate of parasitism by the two torymids, *Philotrypesis pilosa* MAYR and *Apocrypta bakeri* JOSEPH to which *C. marchali* generations are subjected. The incidence of parasitism as calculated in six different generations was found to vary between 3.2 % (for May generation) to 65.6% (for November generation) in

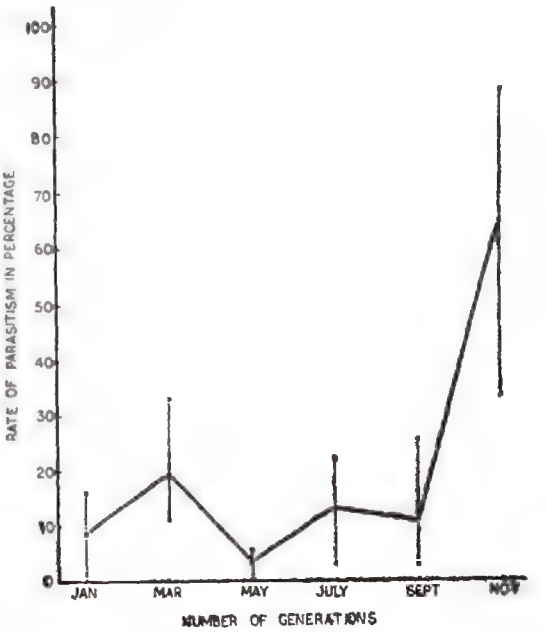


Fig. 11. Parasitism by *Philotrypesis pilosa* MAYR on *C. marchali* during six generations in a year.

P. pilosa (Fig. 11) and from 6.1% (for May generation) to 49.4% (for March generation) in *A. bakeri* (Fig. 12). The *Ceratosolen* larvae that are thus parasitized, irrespective of the sex into which they may develop, are killed by the more competent torymid larvae thereby upsetting the otherwise little fluctuating sex ratio.

In *Blastophaga psenes*, the different aspects of oviposition were studied by GASPARRINI (1865), SOLMS–LAUBACH (1882) LONGO (1909) and GRANDI (1929). GALIL & EISIKOWITCH (1969) studied oviposition of *Ceratosolen arabicus* MAYR which breeds in *Ficus sycomorus*. In *C. marchali*, the manner of oviposition is similar to that of *C. arabicus*.

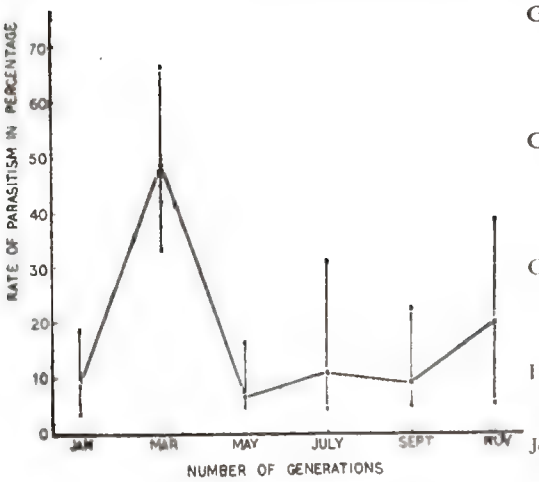


Fig. 12. Parasitism by *Apocrypta bakeri* JOSEPH on *C. marchali* during six generations in a year.

The number of generations of fig wasps in *Ficus hispida* completed in a year was found to be six. HILL (1967) reported four crops of figs of *Ficus hispida* in a year in Hong Kong.

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BIOECOLOGICAL STUDIES ON SOME AQUATIC HEMIPTERA – NEPIDAE

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A study of the biological and ecological aspects of four species of aquatic Hemiptera belonging to the family Nepidae with details on oviposition preferences, duration of postembryonic development, growth rates of body parts during postembryonic development, and population periodicity are presented.

INTRODUCTION

Information relating to the bioecological aspects of aquatic Hemiptera in India appears meagre, being limited to the species *Ranatra filiformis* FAB. (NOWROJEE, 1911), *Sphaerodema rusticum* FAB. (PRESSWALA & GEORGE, 1936) and *Ranatra elongata* (RAO, 1962). An understanding of the modes and preferences of oviposition, growth rates of different structures during postembryonic development, structural adaptations as well as population periodicities appear essential in bio-ecological studies. An attempt is made here to study on comparative basis species of two genera *Ranatra* and *Laccotrephes* (Nepidea). *Ranatra* is cosmopolitan, while *Laccotrephes* is confined to the old world.

MATERIAL AND METHODS

Aquaic Hemiptera collected from different habitats were reared in the laboratory in small glass jars or aquaria provided with natural vegetation. Nymphs were isolated and reared separately in small containers. Adults were fed with *Anispos bouvieri* and nymphs of dragonflies and mayflies.

For the study of seasonal fluctuations, insects were collected weekly from different localities, with a pond net wielded for about 30 minutes, and the sampling areas were chosen in transects so as to cover the entire pond. The insects collected were calculated per metre sq. area.

Measurements of nymphal instars were made 48 hours after moulting, with an eye piece micrometer. For microscopic mounts, material preserved in 70% alcohol was treated with 5% KOH, washed in distilled water, passed through alcoholic series, cleared in clove oil and mounted in Canada balsam.

OBSERVATIONS

Habitat

The permanent pond is about 1.3 hectares, oval and about 1.8 metres deep. The temperature ranges between 21.8° C and 37.6° C. During October and November, water is turbid due to rains. The pH varied from 7.8 to 9.2. Blue green algae grew in the water, the dominant forms being *Microcystis* sp., *Oscillatoria* and *Nostoc*. Fairly abundant zooplankton and submerged vegetation also occur in the ponds.

R. filiformis mostly occurs amongst vegetation fringing the shallower parts of the pond at depths of 30–60 cm clinging to submerged vegetation, and is scarce in deeper areas of pond. *R. elongata* inhabits temporary water puddles existing from October to March. Adults of *R. elongata* prefer deeper parts of pools. *Laccotrephes robustus* inhabits among decaying vegetation along the edges of the temporary pools, while *L. griseus* commonly occurs in habitat with dark soil matching its body colour, in permanent pond near the edges.

Feeding habits

Under natural conditions, adult *R. filiformis* feeds on live nymphs of dragonflies and mosquito pupae caught between the raptorial forelegs. *Anisops bouvieri* and nymphs of dragonflies and may flies were provided in the laboratory to the adults. With a view to evaluate the degree of food preference two different prey species were offered at the same time in equal numbers; the preferred prey were once again offered in equal numbers along with a third species of food prey. Ten replicates were made during this experiment and it was found that the species of *Anisops*, tadpoles, nymphs of Odonates and mayflies come in order of preference. The nymphs of *R. filiformis* on the other hand were observed to prefer the larvae of mosquitoes.

In the field *R. elongata* is seen to feed on tadpoles, species of *Anisops*, nymphs of Odonates, mayflies and other species of aquatic Hemiptera. In the laboratory, the adults seem to prefer larger prey such as big tadpoles, adult notonectids, corixids and *Anisops*. The nymphs prefer larvae of mosquitoes and nymphs of *Anisops*.

Oviposition

R. filiformis lays eggs inside the tissues of aquatic plants while *R. elongata* lays eggs on the substratum. The eggs of *R. filiformis* are laid in rows along the length of stem, with the anterior part of the eggs hidden from the view of predators. Though *Hydrilla*, *Ceratophyllum*, *Elodea* and *Marsilea* were used for oviposition in the aquarium, *Marsilea* is preferred for oviposition followed by *Elodea*, *Hydrilla*, *Vallisnaria* and *Ceratophyllum*. The sharp ovipositor with serrated edges is well adapted to pierce the soft tissues of plants.

In *L. robustus* an average of eighteen eggs are laid in groups of five to six on loose soil or in decaying vegetation, during November–December. The eggs are not covered by soil or mud. In *L. griseus*, the eggs are laid along the edge of the pond glued in a mass to sand grains, the distal ends of the filaments being free. The period of incubation varies. During the monsoon the eggs take 9 days to hatch, while in March they hatch in 6 days.

The nature and number of filaments on the egg appears species specific, with *R. filiformis* bearing a pair of long filaments, while the more elongate eggs of *R. elongata* bear two shorter filaments. Similarly, the eggs of *L. griseus* have ten short filaments, while those of *L. robustus* bear six filaments. Details pertaining to the nature of the eggs of the four species discussed are summarised in Table I.

TABLE 1. Measurements of eggs of different species in Nepidae.

Species	Colour	Shape	Filaments	Length in mm	(Width in mm)
R. filiformis	Pale yellow when laid; white in 24 hrs.	Oval	2	2.0–2.25	(0.75–0.78)
R. elongata	White	Oval	2	2.8–3.1	(0.84–0.86)
L. griseus	Pale white	Oval	6	1.5–1.7	(0.5–0.70)
L. robustus	White	Oblong	10	2.5–2.8	(1.45–1.65)

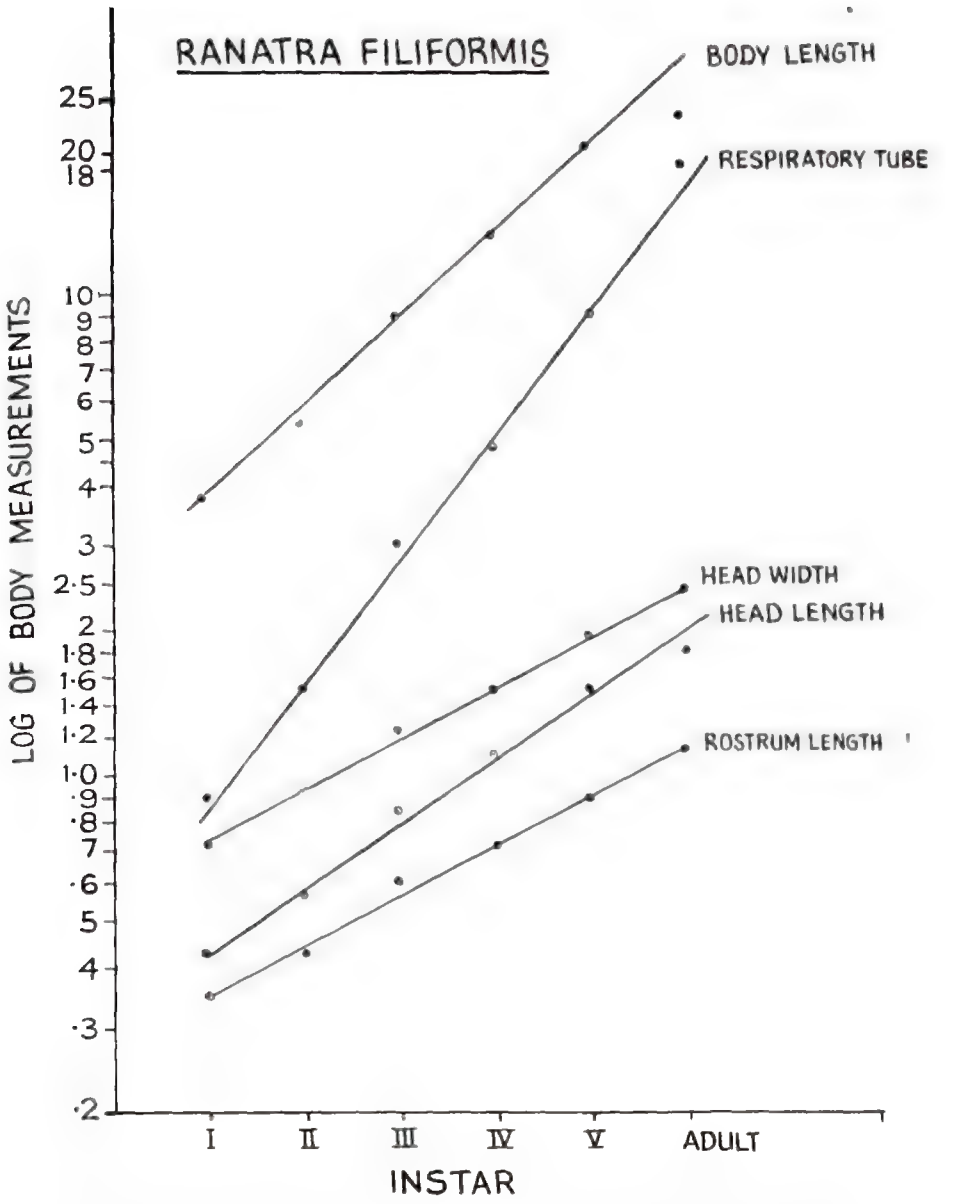

Fig. 1. Measurements of various organs plotted semilogarithmically against instars (Average of six individuals).

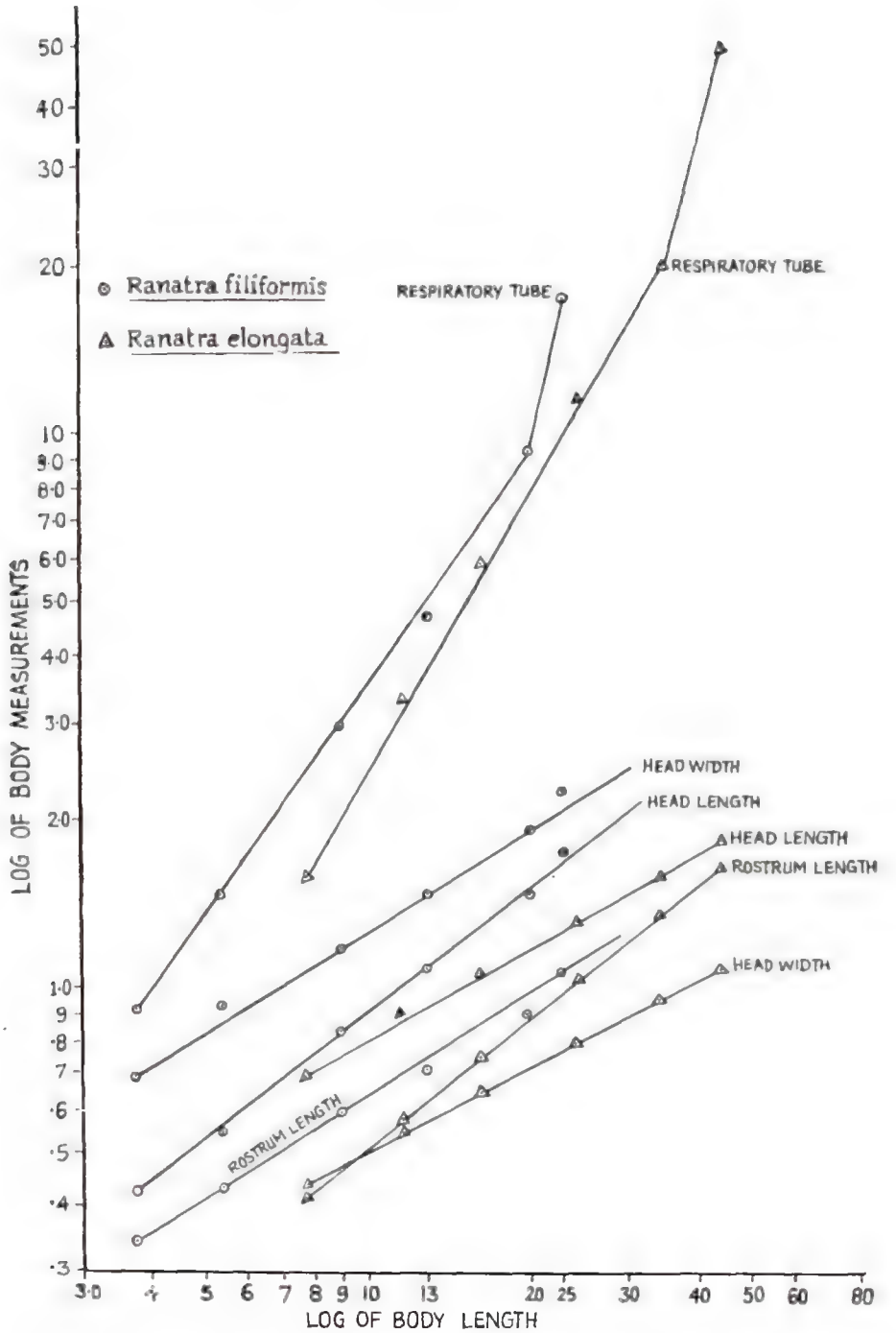

Fig. 2. Body measurements of *R. filiformis* and *R. elongata* plotted logarithmically against total body length (average of six individuals).

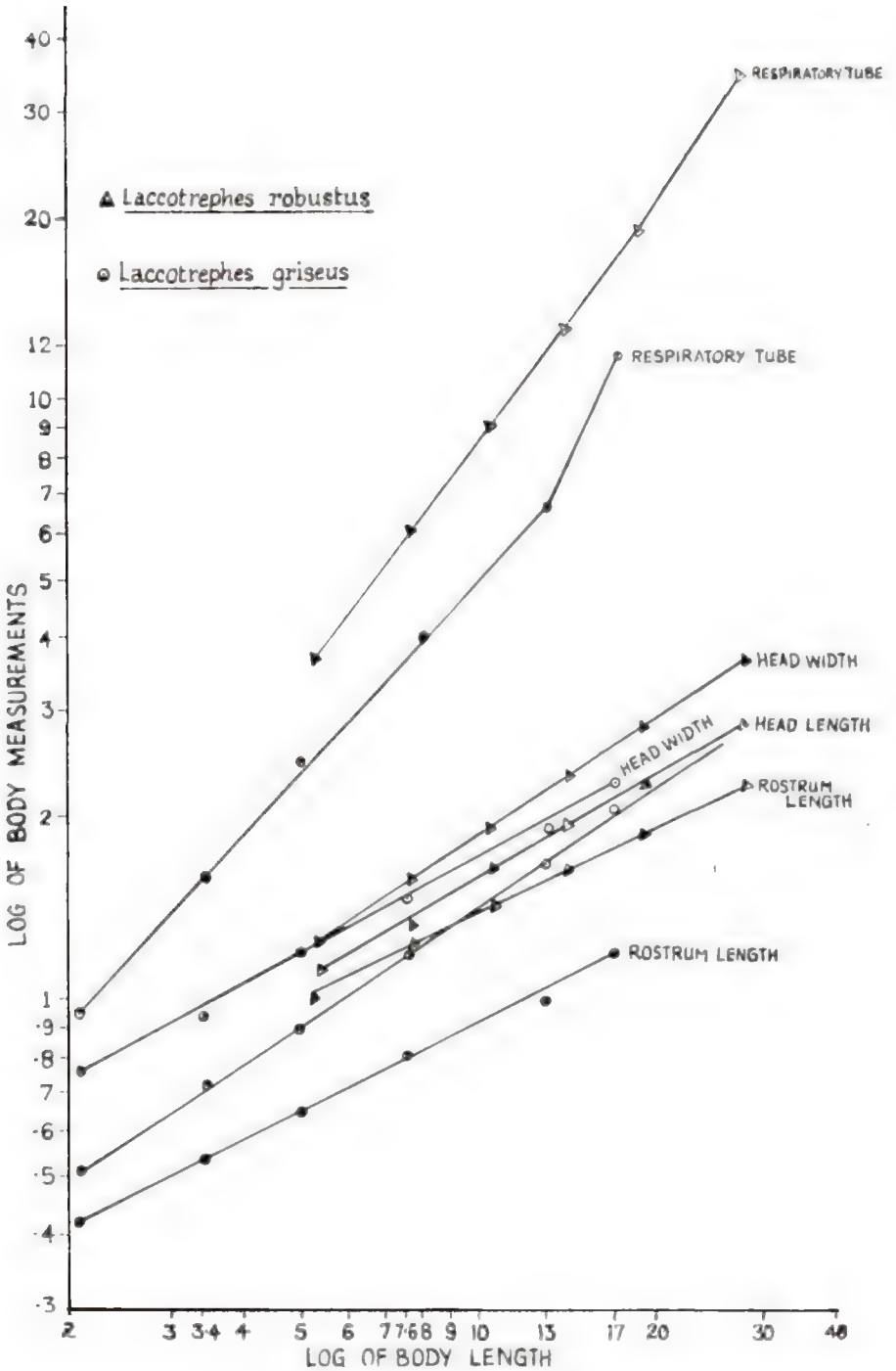

Fig. 3. Body measurements of *L. robustus* and *L. griseus* plotted logarithmically against total body length (average of six individuals).

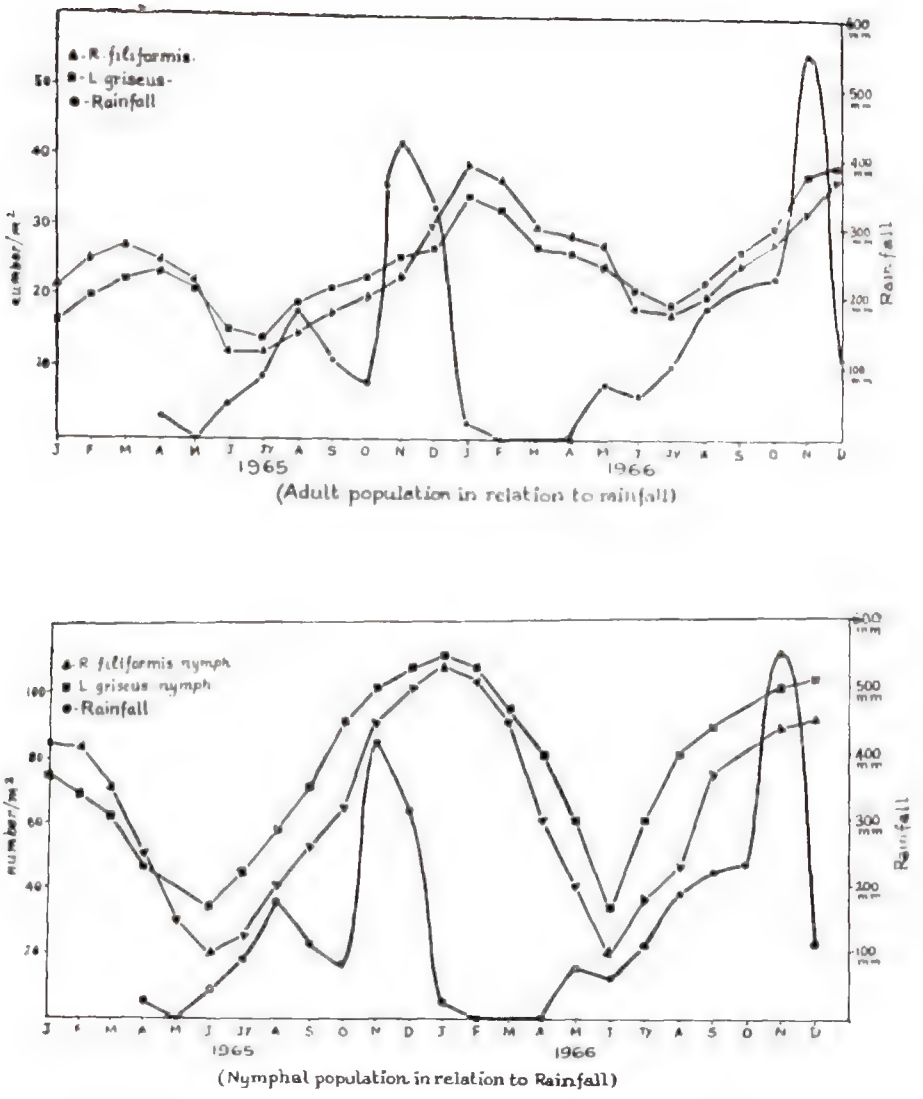

Fig. 4. Relationship between rainfall and population density of the adults (above) and of the nymphs (below) of *R. filiformis* and *L. griseus*.

Postembryonic development and growth

The duration of development from first instar to adult is 35–52 days for *R. filiformis*, 33–40 days for *R. elongata*, 36–53 days for *L. griseus* and 30–46 days for *L. robustus*. An insight into the growth rate of siphon, head and rostrum etc. clearly indicated the nature of their variation in the different species. HUXLEY (1924) proposed the formula $y = bx^k$, where y is the organ growing allometrically in relation to body size or to any other organ whose growth is taken as standard x. Taking the total body length as the standard x, using the lengths of various organs for growing parts y at each developmental stage, the data was fitted into the formula $\log y = \text{Log } b + k \log x$ derived from $y = b^k$. When plotted semilogarithmically against instars, the average measurements for lengths of body, head and rostrum fall nearly on straight line indicating constant rates of growth. Growth gradients of different organs of the Nepidae studied are shown in Figs. 1–3.

Population periodicities

The rate of oviposition of *R. filiformis* is highest in the rainy season, the total number of eggs laid by a female during a period of 70 days being 182. The population density in the permanent pond was recorded throughout the year to ascertain the fluctuation of population and the factors affecting it. It was expressed as number/sq. metre (Fig. 4) which shows a tendency for increase during the monsoon and decrease in summer. As a result of heavy rainfall, favourable temperature, and increase in food prey such as mayflies, odonates and mosquitoes *R. filiformis* breed at a rapid rate. *R. filiformis* eggs appear to suffer little mortality as they are laid inside tissues of aquatic plants, hidden from predators. Moreover the filaments projecting from the eggs give a deceptive appearance. A remarkable similarity in the mode of oviposition exists between *R. filiformis* and *Anisops* the latter exhibiting the same trait as the predator, choosing *Ceratophyllum* and the leaf of *Hydrilla* for oviposition. *R. elongata* lays an average number of 7.3 eggs per day.

Laccotrephes increases in numbers in the rainy months. The fecundity of the species is also very high during this period. Following the monsoon period, the number of eggs laid is on the decrease, so that the population in summer is low (Table 2).

Food chain

R. filiformis being predatory in habit, preys upon the immature stages of the above mentioned insects besides species of *Anisops* which is the most favoured prey. In the field *Anisops bouvieri* is found in great numbers in monsoon season. An increase of *Anisops* population in these months coincides with the corresponding growth of population of *R. filiformis*. Adult *Anisops* and its nymphs feed on *Aedes* and *Culex* larvae. Thus, there appears to be a food chain at the end of which is the predator *R. filiformis*. The nymphs of the advanced stages prey on the younger stages.

Predation of *R. filiformis* by other insects in the pond is not known to occur except in rare cases when it is preyed by *Sphaerodema annulatum*. Various factors in summer reduce the number of this species as also its food prey. When there is a decrease in the food prey in summer there is a depletion in the population.

In the temporary habitat, there is plenty of food available in the rainy season. The temperature and the rainfall bring about the optimum conditions necessary for survival. In April when the pond dries

TABLE 2. Relationship between climatic conditions and duration of incubation of Nepids recorded (based on ten individuals) during the year 1966

Month	Total Rainfall in mm	Mean Max. Temp.°C	average number of eggs/individual				period of incubation (average) in days			
			R.filiformis	*R.elongata*	*L.robustus*	*L.griseus*	*R.filiformis*	*R.elongata*	*L.robustus*	*L.griseus*
January	24.2	28.4	11	19	10	17	11	8	8	9
February	—	29.9	8	4	10	9	9	8	7	8
March	—	34.1	15	8	8	6	8	5	6	7
April	0.8	33.7	14	3	4	5	7	5	5	6
May	81.7	37.9	6	—	—	4	7	—	—	6
June	65.5	35.5	4	—	—	6	9	—	—	7
July	102.7	34.3	5	—	—	—	9	—	—	—
August	190.2	33.8	18	—	11	5	8	—	8	9
September	223.6	31.8	10	—	8	8	10	—	9	8
October	230.3	30.6	16	15	16	28	9	7	7	9
November	556.3	30.0	11	16	14	12	11	8	9	9
December	112.6	28.3	17	18	18	15	12	9	10	12

some of the inhabitants migrate to other more permanent ponds. *R. elongata* and *L. robustus* are such migrants. Migration of these species takes place in summer to tide over unfavourable conditions and a similar behaviour was also observed in *R. filiformis*.

DISCUSSION

The habitat preferences appear well marked, with *R. filiformis* and *L. griseus* occurring only in permanent ponds, lakes, rivers and *R. elongata* and *L. robustus* inhabiting temporary ponds. The modes of oviposition of the species are correlated with the type of habitat. *R. filiformis* lays eggs inside the tissues of plant, while *R. elongata* drops the eggs loosely on the substratum. NOWR JEE(1911) and HOFFMANN (1930, 1933) have reported oviposition in aquatic vegetation by *R. filiformis*. The mode of oviposition in *R. elongata* also appears to be similar to that of *R. chinensis* (HOFFMANN, 1930).

As seen in the present study, from October to February there is a trend towards increase of population due to such physical factors as rainfall, temperature, abundance of food etc., while from April to August there is a decrease in population of aquatic Hemiptera. A heavy rainfall increases the population in monsoon seasons while poor rainfall has an adverse effect in the growth of population.

The egg of *Ranatra* has been the subject of investigation by many authors. PETIT (1902) attributed a protective function to the filaments against predators. BUENO (1906) described the mode of oviposition in plant tissues by *R. quadridentata*. BROCHER (1911) has reported similar mode of oviposition in *R. linearis* while HOLMES (1907) has made similar observation on *R. quadridentata*. HUNGERFORD (1919) indicated that eggs are laid in the stem of aquatic vegetation by *Ranatra* sp. and JORDAN (1925–27) has reported that eggs of *R. linearis*, about six to eight in number, on floating reeds, and rarely in leaves. Mention has not hitherto been made about the preference of the plant for oviposition though

JORDAN (1925–27) indicated that eggs were laid rarely in leaves. Present study shows a preference for the stem of *Marsilea* by *R. filiformis*.

The period of incubation varies from species to species and for the same species in different places. For the eggs of *R. filiformis* an incubation period of four days was reported by NOWROJEE (1911) in Delhi, while at Canton, HOFFMANN has given a period of nine to ten days for the same species. The present study reveals that in Madras the incubation period is six to twelve days. BUENO (1906) has given a period of fourteen days for the eggs of *R. quadridentata* to hatch, while JORDAN (1925–27) has reported thirty two to thirty nine days for *R. linearis* in Germany. An incubation period of eight days was reported in the case of the eggs of *R. chinensis* (HOFFMANN, 1930), while the eggs of *R. elongata* discussed here take five to nine days to hatch. The incubation period of eggs at different temperature in different places may be correlated with their ability to adjust to different climatic conditions. Around Madras eggs laid in rainy months take a longer time to hatch, while those laid in summer take shorter time.

The postembryonic duration varies from species to species and for the same species in different places. The short period of incubation and postembryonic duration of about thirtyfour days reported by NOWROJEE (1911) for *R. filiformis* at Delhi, may be due to the warm climate in April when his studies were made. HOFFMANN (1930) has reported a shorter postembryonic duration of thirtyfive days for the larger species *R. chinensis* and a comparatively longer duration of 42.5 days for the smaller species *R. filiformis*. Similar observations were made in the present studies. It is interesting to note that a larger species shows a shorter duration for nymphal development. It could be seen from the present study that the biology of this species is related to its habitat. Considering the fact that *R. elongata* is an inhabitant of temporary pool, a rapid development of the egg and nymphal stages would be of great survival value in such ephemeral habitats.

In the two species of *Laccotrephes*, habitat preferences are marked. *L. griseus* is seen in permanent ponds, lakes and rivers. In fact most of the records of collection are from rivers and tanks. *L. robustus* is seen in temporary bodies of water. The mode of oviposition differs in the two species studied. *L. griseus* lays eggs inside the moist soil covering the eggs with mud, while the latter is seen to drop the eggs on the substratum. In this habit, *L. robustus* resembles *R. elongata* in not concealing the eggs. A similar mode of oviposition was observed by HOFFMANN (1927) and by HALE (1924) in *L. tristis*.

Studies on the post-embryonic growth of the different parts of the body seem to follow the law of simple allometry in the case of species of Nepidae studied. The postembryonic growth of the respiratory siphon in all the four species studied shows that similar allometric growth patterns apper to exist for the respiratory siphon within the group. This is supported by MATSUDA (1963) who observed that in a group of related species, the growth pattern of segments with higher growth ratios are more similar than that of the other segments with lower growth ratios.

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OBSERVATIONS ON THE FEEDING HABITS OF ORIBATID MITES FROM THE SOILS OF KERALA (ACARINA: CRYPTOSTIGMATA) - PANPHYTOPHAGES

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Employing suitable staining procedures analyses of the gut contents of ten species of oribatid mites collected from field were made and it was found that they fed on decaying parts of higher plants as well as microflora and were therefore assigned to the category of panphytophages. Eight species were reared in the laboratory and were offered about 20 different types of food. Some of these latter species showed feeding reactions which did not agree with the conclusions drawn from gut content analyses of individuals collected from the field. This was thought to be partly due to starvation leading to the acceptance of unnatural diets. None of the species was found to accept animal matter dead or alive as food. Generally nymphal and adult stages of the same species showed similar preference to food though there were exceptions with regard to some food items. No two species reared in the laboratory were found to have exactly the same food preference. The species considered here were thus found to occupy more or less different 'food niches'. The study also indicated that species like *Archegozetes longisetosus* could play a significant role in the breakdown of leaf litter.

INTRODUCTION

The food habits of oribatid mites, mostly of the temperate region, have been studied by a number of workers (LUXTON, 1972). In general such studies have provided information on the ability of the mites to utilise different types of food substances and thus led to their categorization into three broad feeding groups by SCHUSTER (1956). Recently LUXTON (1972) added three more categories to those of SCHUSTER (1956) and coined the term panphytophage for mites which fed on decaying parts of higher plants as well as microflora. The present study has been planned as part of a general ecological work. The taxa dealt with here have not been the subject of study by any previous worker. Since observations on the same species sometimes showed regional differences in the food habits as in the case of *Xenillus* sp. (BERTHET, 1964; LUXTON, 1972) study of the food habits of at least the more common forms becomes obligatory in the proper understanding of the aspects of ecology of these mites like their energy source, distribution, interrelationship of the species and their role in the decomposition of organic matter.

MATERIALS AND METHODS

Ten species of mites obtained from soil and litter were separated specieswise and transferred to plastic boxes 6 cm in diameter and 4 cm in height containing plaster of paris-charcoal mixture in the ratio 4 : 1. Feeding habits were studied by observing the gut contents of individuals collected from the field and by observing the feeding reactions towards food substances provided in the laboratory. Gut contents of 15 individuals of each species were dissected out in a small quantity of glycerine, fixed in 80% ethyl alcohol, centrifuged and stained in a saturated solution of phloroglucinol in 18% HCl to stain vascular elements or 0.2% fast green in 95% alcohol to stain cellulose cell wall of the epidermal and parenchyma cells or 0.5% orange G in 95% alcohol to stain fungal hyphae and spores as given in CONN (1961). Identification of the plant

materials was done following SASS (1959) and FOSTER (1960).

A variety of substances listed in Table 2 were provided in the cultures as food and the reactions of the mites noted. Each feeding test was continued for 5–10 days. The rate of production of faecal pellets was considered as an index of feeding represented in a nominal scale. Absence of animals on the food materials and consequently lack of production of faecal pellets was considered as a definite instance of rejection.

RESULTS AND DISCUSSION

Table 1 gives the results of the analyses of the gut contents of ten species of mites collected from the field. The presence of parts of vascular bundles with secondary thickening in the faeces was considered as indicative of wood feeding while that of leaf epidermal cells and parenchymatous elements as evidence of leaf feeding. The fungus feeding was naturally indicated by the presence of hyphae and spores which could be clearly distinguished in the faeces. Out of the ten species mentioned above the feeding habits of eight species of mites could be studied in the laboratory and the results are given in Table 2.

LUXTON (1972) noted that a number of earlier workers had rather mistakenly assigned several oribatid species to inappropriate feeding categories. The food habits of a species ought to be studied both under laboratory and field conditions before it is assigned to any particular feeding category. The data collected in the present work following these two lines of approach permitted to assign the ten species studied to the panphytophage group. *E. pallida pacifica* and *Galumna flabellifera orientalis* presented some difficulty as they rejected all the seven species of fungi offered to them in the laboratory. This would happen when the fungi offered in the laboratory were unpalatable to the animals as observed by MITCHELL & PARKINSON (1976) in *Eremaeus* spp. Further, the studies of HARTENSTEIN (1962), LUXTON (1966, 1972) and SHEREEF (1972) showed that the oribatid mites exhibited considerable selectivity to microflora. In the present study out of the seven species of fungi offered only three were consumed and of these latter *Alternaria* sp. was found to be preferable to *Cladosporium* sp. and *Trichoderma* sp. Further *All.*

TABLE 1. Gut content analysis of oribatid mites collected from the field

Sl. no.	Species studied	Types of food identified			
		Leaf	Wood	Fungus	Pollen
1.	*Epilohmannia pallida pacifica*	*	* (stem periphery)	*	
2.	*Annectacarcus trivandricus*	*	*	*	
3.	*Galumnella angustifrons*	*	**	**	**
4.	*Otocepheus trivandricus*	** (dry leaf)	**	*	
5.	*Heptacarus hirsutus*		**	*	
6.	*Allonothrus giganticus*		**	**	
7.	*Galumna fabellifera orientalis*		*	*	
8.	*Archegozetes longisetosus*	*		**	
9.	*Basilobelba retiarius symmetrica*	*		*	
10.	*Eremulus wallworki*	**		**	

* low amount

** high amount

Blank space indicates absence

giganticus and *B. retiarius symmetrica* could feed only on a single type of fungus each.

The analyses of the gut contents of the individuals collected from the field gave the impression that within a major category like the panphytophages the members would exhibit certain degree of food selection. This discrimination was first evidenced by the lack of leaf material in the gut contents of *H. hirsutus*, *All. giganticus* and *Galumna flabellifera orientalis* and lack of wood in the gut contents of *Arch. longisetosus*, *B. retiarius symmetrica* and *E. wallworki*. Regarding their restricted choice the laboratory studies confirmed the feeding preferences in the field of *Arch. longisetosus* and *B. retiarius symmetrica*, while *H. hirsutus*, *All. giganticus* and *Galumna flabellifera orientalis* showed that they could thrive on both wood and leaf in the laboratory though they fed on only one of the above two items in the field. It is possible that starvation would force some animals into accepting unnatural diets although it is not known whether such exigencies occur in nature. Feeding of *All. giganticus* on yeast and the alga *Protococcus*, of *Galumnella angustifrons* on fresh moss, *Ann. trivandricus*, *All. giganticus* and *B. retiarius symmetrica* on lichen also perhaps indicates only the ability of these mites to survive on these substances when normal food materials are not available. HARTENSTEIN (1962)and TADROS (1973) found that yeast was not acceptable to the oribatid mites studied by them while BUTCHER *et al.*

TABLE 2. Food preference of Oribatid mites in the laboratory

Sl. no.	Species studied	1 Brewer's yeast	2 *Protococcus*	3 *Trichoderma*	4 *Cladosporium*	5 *Alternaria*	6 Lichen	7 Moss	8 Decomposed leaves	9 Decomposed twigs and stems
1.	*E. pallida pacifica*								x	
2.	*Ann. trivandricus*						x		x **	xx *
3.	*Galumnella angustifrons*		x							x
4.	*H. hirsutus*								x	xx **
5.	*All. giganticus*	xx **				x **	xx *		x	xx
6.	*Galumna flabellifera orientalis*		x			xx **			xx *	
7.	*Arch. longisetosus*			x		**		x *	xx **	
8.	*B retiarius symmetrica*				x		x		x	

xx/** highly palatable
x/* lowly palatable
x indicates feeding by adult
* indicates feeding by nymph
blank space indicates rejection.

Items of food offered but rejected by all species of mites.

Penicillium, *Pythium*, *Colletotrichum*, *Agaricus*, partly decomposed cladodes & seeds of *Casurina*, bark of higher plants, faecal pellets of Oribatid mites, minced meat and small soil animals.

(1971) found that several species of oribatid mites could be reared on yeast. Similarly ROCKET & WOODRING (1966) found that nematodes are avidly eaten by some oribatid mites. In the present study none of the mites accepted animal matter dead or alive.

Out of the eight epecies of mites reared in the laboratory the feeding habits of the nymphal stages of five species could also be observed. LUXTON (1972) noted that in *Damaeus clavipes*, *Belba corynopus* and *Hypochthonius rufulus* there was considerable difference between immature and adult stages in the feeding habits under laboratory conditions while PANDE & BERTHET (1973) found no such differences in food habits between immature and adult stages of oribatid mites under field conditions. In the present study it was found that nymphs and adults generally fed on the same substances except in *Arch. longisetosus* where the nymphs fed on *Alternaria* which the adults rejected and the adults fed on *Trichoderma* which the nymphs did not feed. In *Ann. trivandricus*, *All. giganticus* and *Galumna flabellifera orientalis* there was difference in the degree of preference between the nymphs and adults for the same material. Comparing the feeding habits of adults of these ten species one would be led to believe that no two species agreed perfectly with each other in their feeding habits. It appears that not only the different species but even within the species the adults and nymphs may occupy fairly dissimilar 'food niches'. This could permit the coexistence of a large number of oribatid species under field conditions. Except *O. trivandricus* all the other species in the present study were obtained from a small bamboo grove.

The role of oribatid mites in the decomposition of organic matter has been variously estimated. EDWARDS & HEATH (1963) believed that these mites contributed little to the decomposition of organic matter in the soil. Both the nymphal and adult stages of *Arch. longisetosus* in the present study apparently could contribute much to the mechanical breakdown of the decaying leaves of certain species of plants. The suggestion of MITCHELL & PARKINSON (1976) that oribatid mites being selective feeders of fungi, would influence the composition and abundance of the fungal species in the soil and thereby influence the decomposition of the organic matter also seems to be highly probable.

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BIOLOGY OF *RIPTORTUS PEDESTRIS* F. (COREIDAE: HEMIPTERA), A PEST OF COWPEA

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Studies on the biology of *Riptortus pedestris* F. (Coreidae : Hemiptera) infesting pods of cowpea have shown that the adults mate 2 to 3 days after emergence and lay eggs 12 to 13 days thence. A female lays about 115 eggs, during an oviposition period of 30 days. The duration of the egg and nymph are about 4 and 16 days respectively. The adult lives for 45 to 47 days. The nymphs and adults damage pea pods by sucking juice out of the fully formed seeds, which as a result shrivel up and become discoloured. Tender pods when attacked fail to develop fully.

INTRODUCTION

Riptortus pedestris F. is recorded as a pest of cowpea and other leguminous plants like tur, soybean, mung, lab lab, *Tephrosia candida* and of the gourd (*Luffa acutangula*) (FLETCHER, 1917; HUTSON, 1920; JEPSON, 1935). In Sri Lanka *R. pedestris* infests tea and citrus (HUTSON, 1937). In spite of its widespread occurrence on various crops, no detailed information on its biology is available. The present paper embodies the results of the studies conducted on the biology of *R. pedestris* and the injury it causes to cowpea on which it has been a serious pest in the Agricultural College Farm, Vellayani, Kerala State, during the past few years.

MATERIALS AND METHODS

Insects required for the studies were collected from cowpea plants in the field. They were reared in glass chimneys on tender cowpea pods. To study the duration of the different nymphal instars, the nymphs were reared individually in specimen tubes, 10 × 3 cm. To observe oviposition and fecundity the adults were confined within cylindrical cages (60 × 35 cm) covered with nylon net. Cowpea vines with pods were provided inside these cages to serve as food and as substrata for egg laying. Values given are the average of at least ten measurements, unless otherwise stated.

OBSERVATIONS AND DISCUSSION

Mating and oviposition

Mating takes place at night; it commences 2 to 3 days after the emergence of the adult and is repeated throughout the adult period. Egg-laying commences 14 to 16 days after emergence, a female laying about 115 eggs during an oviposition period of about 30 days. Eggs are laid singly on the pods, mostly towards their basal region.

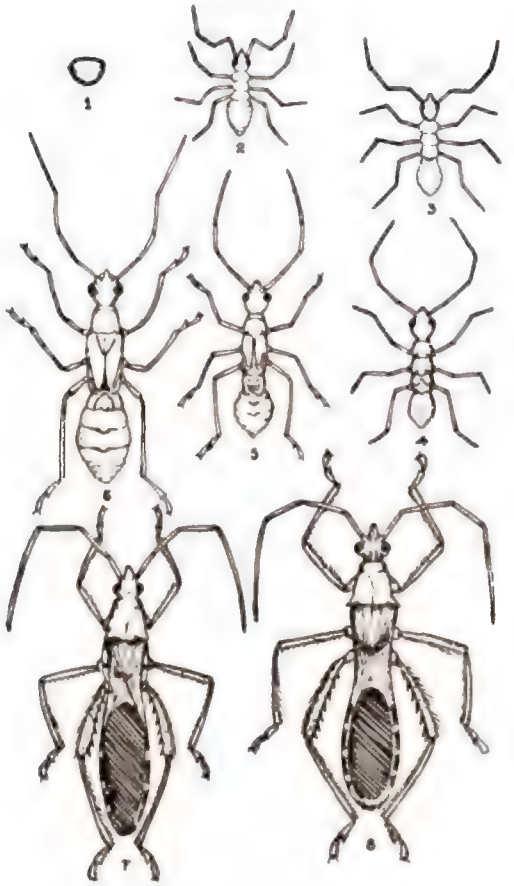
The egg (Fig. 1)

The egg is brownish-black and hemispherical. It measures 1.08 mm × 1.35 mm and is attached to the substratum on its globular side. Incubation period ranges from 3 to 4 days and the nymphs crawl out by pushing out the flat operculum.

The nymph (Figs. 2 to 6)

There are five nymphal instars, the salient features of which are given in Table 1.

The nymphs are elongated with long legs and antennae and have the general appearance of ants with which they are easily mistaken. The newly emerged nymph is reddish, which turns dark brown subsequently. The later instars are orange-



Figs. 1 to 8 : Life stages of *R. pedestris*
1. egg; 2. 1st instar nymph; 3. 2nd instar nymph; 4. 3rd instar nymph; 5. 4th instar nymph; 6. 5th instar nymph; 7. Adult male; 8. Adult female.

coloured immediately after moulting and turn brownish black towards the end of each instar. Head is diamond shaped with rostrum and antenna 4 segmented. The thoracic segments are of equal size. The prothoracic shield from the 3rd instar onwards is produced posterolaterally into pointed processes. The metathoracic tergum medially on its posterior margin is produced upwards into a curved pointed process. This process is more prominent in the later instars. Wing buds appear from the 3rd instar onwards. Abdomen is spindleshaped and bulging, the first abdominal segment being of the same width as the thoracic segments. The posterior margins of the 4th and 5th abdominal segments are produced backwards mid-dorsally into semicircular black flaps. The nymphs are very active. But during the warmer hours of the day they remain clustered under dried up leaves on the plant.

The adult (Figs. 7 and 8)

The adult is dark brown with two black bands ventrally on the abdomen; prominent white spots are seen laterally on the thorax in males. Females are easily distinguished by their bulging abdomen. The adult has a longevity of 45 to 47 days. The adults are active and swift fliers.

TABLE 1. Important features of the nymphs and adults of *R. pedestris*. Values represent average of ten measurements

	Instars					
	I	II	III	IV	V	Adult
Body length (mm)	3.05	5.50	7.69	10.00	13.00	15 00
Width of thorax (mm)	0.50	0.75	1.12	1.71	2.70	3.00
Head width (mm)	0.85	1.13	1.41	1.86	2.16	2.64
Length of rostrum (mm)	1.35	2.49	3.04	3.89	5.32	5.89
Length of antenna (mm)	3.21	5.80	7.18	9.40	9.70	13.00
Duration (in days)	3.00	3.60	3.00	3.75	3.16	...

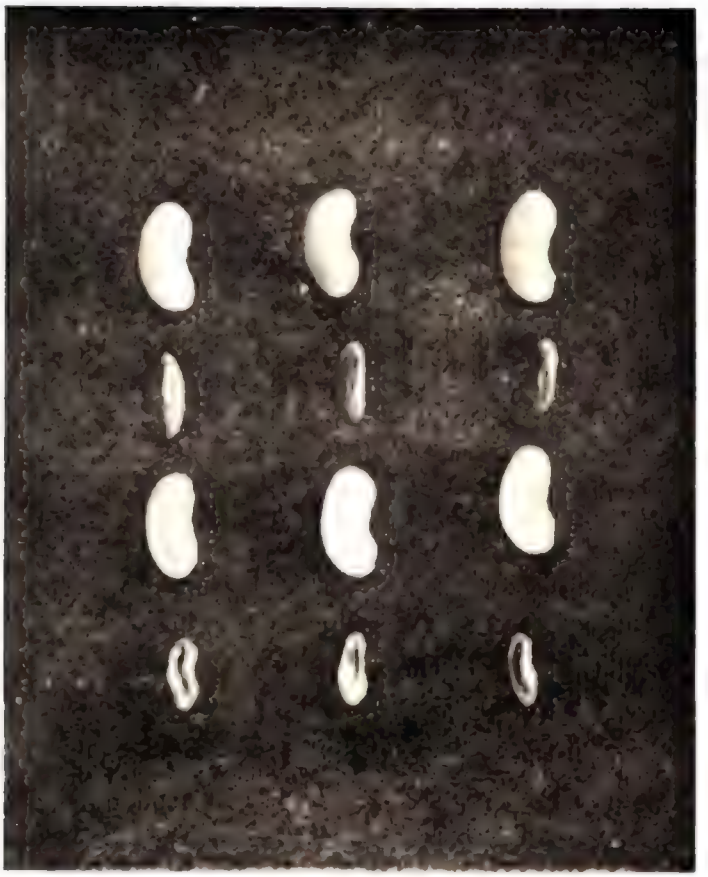


Fig. 9 : Damage caused by *R. pedestris.*
1st row : Healthy seeds; 2nd row : Damaged seeds;
3rd row : L. S. of healthy seeds; 4th row : L. S of damaged seeds.

Damage caused (Fig. 9)

The nymphs and adults feed by sucking juice from the seeds. The feeding punctures are seen on the pods especially localised in the regions where the seeds are located. The pods with fully formed seeds are preferred for feeding. The attacked seeds shrink and shrivel up within the pods and are discoloured. The skin surface of such pods become rough and uneven. The tender pods when attacked fail to develop fully and become totally useless. In the case of grown up pods the seeds are destroyed rendering them unfit for culinary and seed purposes Similar damage to pods of soybean by *Riptortus atricornis* has been reported by RODRIGO (1947) and to pods of beans by *R. seripes* by CALDWELL (1945).

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PHYSIOLOGICAL ACTION OF CERTAIN INSECTICIDES AND THEIR TOXINS ON ISOLATED COCKROACH HEART

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The physiological action of endrin, malathion and neurotoxins liberated by them was studied on isolated cockroach heart. In the action of malathion acetylcholine is involved and it does not paralyse the cardiac ganglia. Contrary to this malathion neurotoxin acts by paralysing cardiac ganglia and acetylcholine is not involved in its action. Endrin and its neurotoxin act at the cardiac ganglia by paralysing them and acetylcholine is not involved in their action.

INTRODUCTION

It has been shown that during DDT poisoning, a toxic substance is liberated into the blood of *Periplaneta americana* L., which by chemical analyses proved to be neither DDT nor its metabolite (STERNBURG & KEARNS, 1952; SHANKLAND & KEARNS, 1959). The neurotoxin released by TEPP. malathion and pyrethrum into the blood of cockroach, when applied to an isolated nerve cord, produced increased spontaneous activity and also an increase in the heart beat frequency (COLHOUN, 1958; SUDERSHAN & NAIDU, 1967). A recent report (PURUSHOTHAM RAO & NAIDU, 1976) has shown that site of action for neurotoxins and nicotine appears to be the same. The present investigation was undertaken to study and compare the physiological action of malathion, endrin and the neurotoxins released by their action.

MATERIALS AND METHODS

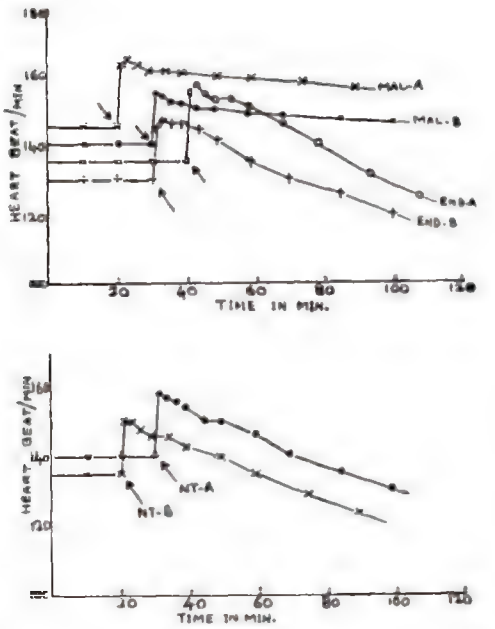
The isolated cockroach heart technique described earlier (KRIJGSMAN *et al*, 1950; NAIDU, 1955) was employed in the present studies. The frequency of heart-beat was taken as a measure of the action of insecticide or neurotoxin and each experiment was carried out on at least five different heart preparations. The mean result of five tests provides the value for each point on the graph. Arrows in the figures indicate the point of addition of test solution to the heart preparation. Laboratory reared male adults of *Periplaneta americana* L. were used for the experiments.

The concentration equivalent to LD_{90} of malathion and endrin dissolved in ethanol was injected intraperitoneally to *P. americana*. Four hours after the treatment blood was collected by centrifugation and the toxic neuroactive substance was isolated as described by STERNBURG *et al.* (1959). Test solutions of insecticides and neurotoxins were prepared in ethanol (wt/vol) while drugs in distilled water and incorporated into the physiological solution. The concentration of ethanol used was found to be not detrimental to the isolated cockroach heart.

RESULTS

Effect of malathion and endrin (Fig. 1)

Malathion (A, 2×10^{-6} μg/ml) caused an immediate increase in the frequency of the heart beat (FHB) which continued for sometime, later a steady decline was observed. At lower concentration (B,



Figs. 1 and 2. Effect of malathion (MAL) and endrin (END) on the isolated cockroach heart (upper) and Effect of malathion –neurotoxin (NT) on the isolated cockroach heart (lower).

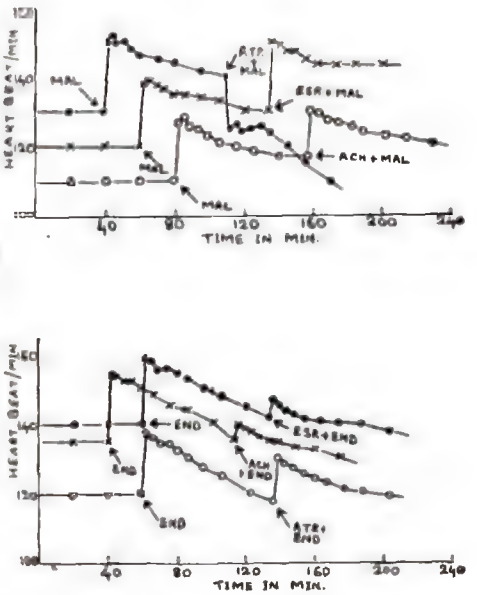
5 x 10^{-7} μg/ml) a similar effect was produced except that the initial increase caused was slightly less. A slight increase in the amplitude was seen. Endrin (A, 5 x 10^{-7} μg/ml) induced an immediate increase in the frequency followed by a rapid decline, this was accompanied by slightly reduced amplitude. At lower dilution (B, 3 x 10^{-8} μg/ml) the initial increase caused was slightly less.

Effect of malathion and endrin toxins (Fig. 2)

Neurotoxin released by the action of malathion (A, 5 x 10^{-3} μg/ml) caused an immediate increase in the FHB which was sustained for some time followed by rapid decline. No apparent change in the amplitude of the heart beat was observed. At lower concentration (B, 2 x 10^{-4} μg/ml) a similar effect on the FHB was seen except that the initial increase caused was less. An identical action was seen with endrin–neurotoxin on the isolated cockroach heart.

Effect of cholinergic drugs on the activity of insecticides

The anticholinesterase, eserine (1 x 10^{-8} μg/ml) by itself had little or no action on the FHB when added to a heart preparation, but potentiated the activity of malathion (5 x 10^{-7} μg/ml). Similar potentiation of malathion was also seen with very low concentration of acetylcholine (2 x 10^{-9} μg/ml) but atropine (5 x 18^{-5} μg/ml) inhibited the action of malathion (Fig. 3).



Figs. 3 and 4. Effect of eserine (ESR), acetylcholine (ACH) and atropine (ATR) on the action of malathion (MAL) (upper) and Effect of eserine (ESR), acetylcholine (ACH) and atropine (ATR) on the action of endrin (END) (lower).

To a heart preparation previously treated with endrin (5 x 10^{-7} μg/ml) addition of eserine (1x 10^{-8} μg/ml) or acetylcholine (2 x 10^{-9} μg/ml) did not cause significant change in the heart beat rate. Atropine (5 x 10^{-5} μg/ml) a cholinergic blocker did not interfere with the action of endrin (Fig. 4). After prolonged treatment of nicotine (5 x 10^{-5} μg/ml) for 3hrs addition of endrin did not cause any significant change in the frequency

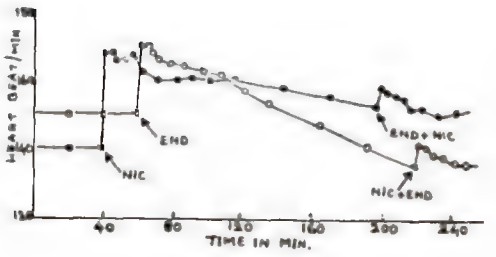


Fig. 5. Effect of nicotine (NIC) on the action of endrin (END) and *vice versa*.

of the heart beat. When the treatment was reversed the action of nicotine was reduced significantly (Fig. 5).

DISCUSSION

The changes produced in the FHB by malathion, endrin and their neurotoxins are similar, suggesting similarity in the site and mode of action of the insecticides and their neurotoxins. However, reaction with cholinergic drugs gave contrary results.

The potentiation of malathion by low concentrations of eserine or acetylcholine suggests the involvement of acetylcholine in its action, which is further supported by the fact that atropine a cholinergic blocker inhibits its action. Earlier findings of NAIDU (1965) showed that nicotine was able to manifest its normal action after prolonged treatment with malathion. If the treatment was reversed, the action of malathion was not seen. It was concluded that malathion does not produce its action by causing paralysis of cardiac ganglia as nicotine does, but by stimulating them.

Eserine or acetylcholine in low concentration do not potentiate the action of endrin and atropine does not antagonise its action. It is reasonable to believe that acetylcholine is not involved in the action of endrin. Further, its action on the cardiac ganglion is evident from the fact that after prolonged action of nicotine, endrin does not cause any change in the FHB.

The authors have recently reported (PURUSHOTHAM RAO & NAIDU, 1976) that after prolonged treatment of neurotoxin released by malathion and endrin, nicotine did not produce any change in the heart beat frequency. The activity of neurotoxins on the heart was neither antagonised by atropine nor potentiated by eserine. It was concluded that neurotoxins act at the cardiac ganglia and acetylcholine is not involved in their action. The present findings on endrin appear to be in agreement with the above contention.

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RESIDUAL TOXICITY OF DEPOSITS OF SOME MODERN INSECTICIDES TO APTEROUS ADULTS OF *MYZUS PERSICAE* SULZER ON POTATO PLANTS

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The residual toxicity of deposits of some systemic and contact insecticides to apterous adults of *Myzus persicae* on potato plants is discussed.

INTRODUCTION

Myzus persicae SULZER, popularly known as green peach aphid is an important vector of potato viruses and is prevalent both in hilly regions and plains of India. Existing literature on insecticidal control of aphid vectors of potato virus diseases reveals phorate (granules), oxydemeton – methyl (E.C.), disulfoton (granules) and dimethoate (E. C.) to be effective (NIRULA, 1962; NIRULA & KUMAR, 1969; ANONYMOUS, 1971; MISRA & VERMA, 1974). The present studies under field-cum–laboratory conditions were carried out to evaluate the residual toxicity of the deposits of some modern (systemic and contact) insecticides on potato plants against apterous adults of aphid, *M. persicae*. The purpose of including the contact insecticides in this trial was to select some residually effective contact insecticides which may be used as a substitute of oxydemeton-methyl (most popular foliar systemic insecticide) and other foliar systemic insecticides under certain situations, especially when the spray treatment is desired to potato crops which are near the harvest.

MATERIAL AND METHODS

Potato variety "*Kufri chandramukhi*" was grown during autumn, 1975 in 3.0 x 2.5 m plots at Simla. Each plot contained 6 rows of 12 plants/row. The plants were spaced at 50 cm between and 20 cm within rows. There were 13 treatments including control which were replicated 3 times in a randomised block design. Six insecticides namely, oxydemeton-methyl (Metasystox E. C), chlorpyrifos (Dursban E. C), dicrotophos (Bidrin E. C.), methyl-parathion (Metacid E. C.), endosulfan (Thiodan E. C.) and thiometon (Ekatin E. C.) were sprayed to drip-point at two concentrations viz. 0.03% and 0.05% actual ingredients. Control plots were sprayed with water.

The treated potato leaves were collected from plots 2 hrs after spraying and subsequently at different intervals till the toxic effect of most of the insecticides disappeared. One compound leaf plucked from each treated plot (representing each replication of each treatment) was kept inside the petridish pairs of 10 cm size every time. Wet blotting paper was provided inside the lower petridishes before keeping the treated leaves for maintaining their normal condition for 48 hours. Ten laboratory reared apterous adults of *M. persicae* were liberated in each replication (each petridish pair containing treated leaf) of each treatment. The petri dishes containing leaf and aphids were kept in an incubator at 22 ± 2°C for 48 hours after which mortality observations were recorded. Residual toxicity of the insecticides was compared on the basis of "PT" index method suggested by PRADHAN & VENKATRAMAN (1962).

RESULTS AND DISCUSSION

During the investigations average maximum and minimum temperatures were 14.0 and 6.0°C, respectively, while average relative humidity was 31.3%. There was no rain/snow fall during this period.

TABLE 1. Residual toxicity of deposits of some modern insecticides to apterous adults of *Myzus persicae* SULZ. on potato plants.

Treatment	% mortality* due to 0.35% insecticides						% mortality* due to 0.05 insecticides					
	First day	Last day	X	T*	P	PT	First day	Last day	X	T*	P	PT
Oxydemeton-methyl (Metasystox E. C.)	100.00	63.33	35+	90.12	35	3154.20	100.00	100.00	35+	99.05	35	3466.75
Chlorpyrifos (Dursban E. C.)	100.00	36.66	30	76.96	35	2693.60	100.00	40.00	34	87.71	35	3069.85
Dicrotophos (Bidrin E. C.)	100.00	36.66	25	63.66	35	2228.10	100.00	30.00	25	72.09	35	2523.15
Methyl-parathion (Metacid E. C.)	100.00	9.16	19	78.47	24	1883.28	100.00	2.50	21	56.77	35	1986.95
Endosulfan (Thiodan E. C.)	100.00	6.66	18	49.85	35	1744.75	100.00	33.33	20	56.52	35	1978.20
Thiometon (Ekatin E. C.)	100.00	5.00	13	50.57	29	1466.53	100.00	20.00	15	52.17	35	1825.95
Control (Water – spray)	0.00	0.00	—	—	—	—	0.00	0.00	—	—	—	—

*Average of three replications; + = upto the last observation date average mortality recorded was above 50%.
X = The number of days upto which at least 50% mortality was recorded; T = Average per cent mortality per day; P = Period in days upto which some mortality was recorded and P T = Residual toxicity index (P × T).

The results are shown in Table 1. It may be seen that two hours old deposits of all the insecticides in both the concentrations caused 100% mortality of *Myzus persicae*. Oxydemeton – methyl, chlorpyrifos, dicrotophos, methyl-parathion, endosulfan and thiometon have descending values of residual toxicity for their deposits.

It would be seen from Table-1 that the pattern of residual toxicity of all the insecticides remained the same at both the concentrations. All the insecticides were found effective against apterous adults of aphid, *M. persicae* under prevailing climatic conditions but oxydemeton-methyl, chlorpyrifos and dicrotophos were relatively persistent for longer period.

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METRICAL MORPHOLOGY AND GROWTH TREND OF THE LARVAL INSTARS OF *PERICALLIA RICINI* FABRICIUS (LEPIDOPTERA : ARCTIIDAE)

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Studies on the larval instars of *Pericallia ricini* show that a particular instar can reasonably be ascertained with the help of morphometric measurements.

INTRODUCTION

Various workers from time to time have established a number of criteria for the determination of the lepidopteran larval instars (CATSUMATA, 1931; NISHIKAWA, 1931; YAGI & KATSUMATA, 1935; KANNO, 1955; LIN *et. al.*, 1964; MURTHY & PERRAJU, 1969; ALLEN & GRIMBLE, 1970). The observations on the growth trend of the cuticular part of insects have been varied (DYER, 1890; GAINES & CAMPBELL, 1935; LUDWIG & ABERCROMBIE, 1940). In the present communication the metrical data and observations on the growth trend of different characters of the larval instars of the castor (*Ricinus communis* L.) leaf eating pest *Pericallia ricini* FAB. are presented.

MATERIAL AND METHODS

The larvae were reared in the laboratory (temperature 28°–32° C and relative humidity 74–90 per cent) on castor leaves. The different parts of the larvae of the different instars were dissected out for taking the measurements. For each larval instar and for each of the variables, there were ten replications. The significance of difference between the mean values was tested by analysis of variance. To ascertain the nature of the growth curve of all the variables, log Y (where Y was the observed mean values of the variables) was calculated against x (where x was the stages of instars) and the relations were linear and nonlinear. The appropriate degree was determined by fitting orthogonal polynomial to the logarithms of the observed mean values of the variables (y), assuming the stages of instars (x) to be equidistant. The appropriate degree of the polynomial was determined by the analysis of variance test.

RESULTS AND DISCUSSION

The morphometric data are presented in Table 1 and the results of the growth trend analysis in Table 2. The linear component in all cases (except antenna length) is significant at 1%, whereas the quadratic component is insignificant. The growth trend of all these variables is thus linear in the logarithms of the variables [$y = \log Y = b_0 + b_1 (x - \bar{x}) = a_0 + b_1 x$] i.e. the relation is exponential in the observed values ($Y = ab^x$ where $a_0 = \log a$ and $b_1 = \log b$). In the equation $Y = ab^x$, b is the progression factor. In the case of antenna length the quadratic component is significant at 5% whereas the cubic component is insignificant. The growth trend of this variable is hence quadratic in logarithms of the variable [$y = \log Y = (y - 5b_1 + 5.001\ b_2) + 2b_1 - 7.5\ b_2)\ x + 1.5\ b_2\ x^2$]. The growth rate, where the trend is quadratic, is negative [$\frac{dy}{dx} < 0$, when $y = f(x)$].

The high significance in the differences of measurements indicates that the particular stage of the instar can reasonably be ascertained with the help of morphometric

TABLE 1. Morphometric data of different larval instars of *Pericallia ricini*.

	Mean values of measurements on different instars						C. D. at 5%	Remarks
	I	II	III	IV	V	VI		
Body weight mg	0.600	0.750	5.300	26.600	97.190	325.050	4.321	**
Body length mm	3.000	4.000	6.000	11.600	17.000	27.700	1.246	**
Body width mm	0.500	0.500	1.160	2.000	3.150	5.040	0.305	**
Head capsule length mm	0.270	0.360	0.690	1.103	1.730	2.440	0.011	**
Head capsule width mm	0.324	0.439	0.801	1.250	1.920	2.718	0.055	**
Labrum length (Antero-posteriorly) mm	0.054	0.072	0.140	0.237	0.330	0.471	0.028	**
Labrum width (Laterally) mm	0.090	0.141	0.225	0.375	0.585	0.834	0.055	**
Mandible length mm	0.090	0.125	0.250	0.380	0.594	0.858	0.028	**
Mandible width mm	0.072	0.100	0.170	0.302	0.474	0.708	0.028	**
Maxilla length mm	0.162	0.248	0.454	0.711	1.083	1.480	0.028	**
Maxillo-labial hypopharyngeal complex width mm	0.198	0.239	0.455	0.729	1.180	1.545	0.055	**
Antenna length mm	0 036	0.072	0.139	0.218	0.339	0.447	0.011	**

** 1% larvel of significance in the differences of mean.

TABLE 2. Growth trend analysis of different morphological characters in larvae of *P. ricini*.

Morphological feature	Values of F		Growth Equation
	Observed F at 1, 3 d. f.		
	Linear	Quadratic	
Body weight	103	0.197	$\log Y = 3.3108 + 0.2958x$
Body length	408	1.080	$\log Y = 3.6825 + 0.1000x$
Body width	98	0.162	$\log Y = 2.8876 + 0.1092x$
Head capsule length	391	0.322	$\log Y = 2.6643 + 0.1004x$
Head capsule width	586	0.553	$\log Y = 2.7367 + 0.0965x$
Labrum length	144	0.049	$\log Y = 1.9623 + 0.0993x$
Labrum width	1888	3.350	$\log Y = 2.2083 + 0.0988x$
Mandible length	80	0.128	$\log Y = 2.1970 + 0.1023x$
Mandible width	671	0.004	$\log Y = 2.0855 + 0.1041x$
Maxilla length	378	2.030	$\log Y = 2.4706 + 0.0992x$
Maxillo-labial hypopharyngeal complex width	235	0.202	$\log Y = 2.4973 + 0.0975x$
	Observed F at 1, 2 d.f.		
	Linear	Quadratic	Cubic
Antenna length	2646	59.700	9.196 $\log Y = 1.5500 - 0.3352x - 0.0228x^2$

measurements. Moreover, the linear relationship in the growth of some characters indicate that the data has a trend to agree with the DYAR's law (DYAR, 1890). The non-linear growth trend of the antenna length, however, supports the view of METCALF & FLINT (1962) which postulates that for some insects the relationship in the growth of different parts of insects is parabolic rather than linear.

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A PRELIMINARY REPORT ON THE FUNGI INFESTING THRIPS (THYSANOPTERA, THRIPIDAE)

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The paper presents the findings on three species of fungi infecting thrips.

INTRODUCTION

There are records of various types of entomogenous fungi occurring on several types of insects and their epizootic outbreaks cause heavy mortality at various developmental stages. Such an epidemic, when severe, can eradicate an insect population completely from a habitat. If such a situation occurs in an important pest it would be worthy of exploitation as a means of biological control. There has been only one report of a fungus from thrips (WILLIAMS, 1915). During the present investigation, it was observed that some species of thrips, which cause considerable damage to their host plants especially in young seedling stage were attackad by fungi. These fungi were identified as *Alternaria alternata* (FR.) KEISSLER, *Cladosporium cladosporioides* (FRESNER) DE VRIES and *Trichothecium roseum* LINK. The thrips attacked by above fungi were *Thrips flavus* SCHRANK, *Scirtothrips dorsalis* HOOD and *Microcephalothrips abdominalis* (CRAWFORD).

MATERIALS AND METHODS

Thrips specimens were collected from nursery of Zoology Department, University of Delhi, Nursery and Botanical Garden, University of Delhi. They were dissected in RINGER'S solution and were stained by cotton blue stain. Smears of the various stages were also air dried, fixed in absolute methanol and stained overnight in GIEMSA stain. Thrips specimens before being studied had been previously surface sterilized by 95% ethanol and washed in distilled water. The paraffin sections of the alcoholic Bouin fixed material were also studied. The stain used for sections was HEIDENHAIN'S iron haematoxylin and eosin.

OBSERVATIOS AND DISCUSSION

Fungi imperfecti are very common parasites in insects. *Alternaria alternata* (FR.) KEISSLER of this group (Demitaceae) is known as plant pathogen causing leaf spot or blight. This species is also found as a contaminant in fungus cultures (Figs. 1 & 2). During the present studies a moderate to heavy infection of this form was observed in *Thrips flavus* SCHRANK (Host plant : *Gossypium hirsutum*). Several free conidia of fungus were seen in the smears (25–30 per larva, when infection was heavy). The period of infestation noted was from December to March. Usually the host cells with several developing stages of *Alternaria* species were observed (Figs. 3 & 4). Mostly the haemocytes were damaged by this fungus. A certain degree of damage was also caused to adipose tissue and gonads. So far no species of *Alternaria* has been reported as insect pathogen or saprophyte, although a related genus *Stemphylium botryosum* WALLR. has been found to infest coccids (STEINHAUS, 1949).

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Cladosporium cladosporioides (FRESNER) DE VRIES (Demitaceae) was found to attack *Thrips flavus* SCHRANK (host plant : cotton) and *Microcephalothrips abdominalis* CRAWFORD) (Host plant: *Tagetes erecta* and *zinnia*) (Figs. 5, 6 & 7). The period of infestation noted was from November 1975 to April 1976. Earlier *Cladosporium aphidis theum* was reported from aphids (STEINHAUS, 1949). The present studies showed a large number of small and big conidia of *C. cladosporiodes* and worn out host tissue cells in smears and sections.

Trichothecium roseum LINK (Moniliaceae) is another fungs commonly observed in *Thrips flavus* SCHRANK (host plant : cotton), *Scirtothrips dorsalis* (HOOD) host plant : castor) and *Microcephalothrips abdominalis* (CRAWFORD). JOLLY (1959) described *Trichothecium roseum* infesting the silkworm larvae heavily and reported the entry of fungus through the integumental wounds. MADELIN (1968) also enlisted *T. roseum* as casual invader of insects gaining entry through ruptured integument. Another species of the same genus *T. acridiorum* has been found to cause damage to red locusts (MADELIN, 1966). The present studies revealed a heavy invasion of the larval stages of thrips by the conidia of *T. roseum*. The conidia were seen on the external surface and were even observed in the haemocoele. *T. roseum* disrupted various organs of the thrips (Fig. 8).

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Fig. 1. *Alternaria alternata* conidium from smears of *Thrips flavus*.
Fig. 2. The conidium of *A. alternata* from *Microcephalothrips abdominalis*.
Fig. 3. Developmental stages of *A. alternata* in the host cell (*Thrips flavus*).
Fig. 4. Developmental stages of *A. alternata* from *aphid (Aphis gossypi)*.
Fig. 5. *Cladosporium cladosporioides* conidia from *Thrips flavus*.
Fig. 6. *C. cladosporioides* and *A. alternata* from aphid.
Fig. 7. *C. cladosporioides* from *Thrips flavus*.
Fig. 8. *Trichothecium roseum* conidia from *Thrips flavus* larvae.

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SEX-BASED DIFFERENCES OF THE GUT AND SALIVARY GLAND INDICES IN THE COCKROACH, *PERIPLANETA AMERICANA**

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Gravimetric studies on the cockroach *Periplaneta americana* reveal remarkably high weight and histosomatic index of salivary apparatus in the female as compared to the male.

INTRODUCTION

The female insect has to satisfy vitellogenic nutritional pressures besides the vegetative requirements which ultimately find expression in higher quantum of food intake. This may lead to a sexual dimorphism in digestive gland index which has not hitherto been examined in insects. In the present communication we report the differences in indices of salivary apparatus and gut of the cockroach *Periplaneta americana*.

MATERIALS AND METHODS

The cockroaches collected from domestic habitats were kept in the vivaria. Adults of both sexes were weighed to the nearest milligram. The salivary apparatus and gut were dissected out, adhering water blotted by filter paper and weighed to the nearest milligram. The gut was cut open and contents removed by rinsing in saline. The emptied gut was reweighed after blotting. The corrected body weight was obtained by subtracting the weight of the gut contents from the body weight determined earlier. The histo-somatic indices (HSI) were calculated for the salivary apparatus and empty gut as the weight of the tissue percent corrected somatic weight. The weights and histo-somatic indices were expressed as sexual dimorphism indices (SDI) applying the formula: SDI =(Female/Male – 1) x 100. The regressions of the tissue weights and HSI's on the somatic weight were computed according to standard statistical procedures (PILLAI & SINHA, 1968).

RESULTS AND DISCUSSION

The total individual tissue weight and HSI of salivary apparatus showed profound sex-based differences (Table 1) whereas the gut weight and its HSI did not exhibit statistically significant sex-based differences. The male : female (M : F) ratios of the somatic weight, gut weight and its HSI were considerably lower than those of the salivary apparatus and its HSI. These sex-based differences were more clearly illustrated by the SDI's (Table 2). The SDI's of gut weight and gut HSI were low and not statistically significantly different from the SDI of somatic weight. But the SDI's of salivary apparatus and its HSI were very high and were significantly different from the SDI's of somatic weight, gut weight and gut HSI.

The regression coefficients of the female

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* dedicated to Dr. S. G. MANAVALA RAMANUJAM.

TABLE 1. Sex differences in histo-somatic indices of salivary apparatus and gut in *Periplaneta americana*.

Parameter	Male	Female	t	df	P	M:F Ratio
Somatic weight in grams	0.964± 0.103(11)	1.241± 0.123(14)	5.931	23	<0.001	100:128.7
Gut weight in grams	0.120± 0.08865(15)	0.1487± 0.04535(10)	1.351	23	NS	100:123.9
Salivary apparatus weight in grams	0.0064± 0.00197(11)	0.0196± 0.00582(14)	7.188	23	<0.001	100:306.2
Histosomatic index of gut (G-HSI)	11.361± 4.422(15)	10.933± 2.307(10)	0.278	23	NS	100:96.2
Histosomatic index of salivary apparatus (SA-HSI)	0.67± 0.217(11)	1.58± 0.491(14)	5.701	23	<0.001	100:235.8

Values under 'Male' and 'Female' are mean ± standard deviation. The numbers of determinations are parenthesized.

t : Students' 't' test value for significance of difference between the compared means: d.f : numbers of degrees of freedom; P : level of significant difference between compared means; NS: not significant.

TABLE 2. Sexual dimorphism indices (SDI) in the cockroach *Periplaneta americana*.

Parameter	SDI
Somatic weight (SW)	+ 18.96 ± 10.7 (10)
Salivary apparatus weight (SAW)	+ 241. 2 ± 119.9 (10)
Histosomatic index of salivary apparatus (SA-HSI)	+ 155. 6 ± 96 61 (10)
Gut weight (GW)	+ 44.808± 66.7 (10)
Histosomatic index of gut (G-HSI)	+ 14.799+ 50.67 (10)

	t	d.f.	P
SW-SAW	5.837	18	<0.001
SW-SA. HSI	4.444	18	<0.001
SAW-SA. HSI	1.758	18	NS
SW-GW	0.679	18	NS
SW-GHSI	0.135	18	NS
GW-GHSI	0.616	18	NS
SAW GW	4.527	18	<0.001
SAHSI-GHSI	4.082	18	<0.001

Values of SDI are means ± standard deviations with numbers of estimation in parentheses.

salivary apparatus weight was positive ($b = +0.00476$) while the 'b' for male was negative ($b = -0.00174$). However these regression coefficients were not statistically significant. Nevertheless the regression lines of the females were at higher levels than those of the males.

One feature of interest which emerges from the present work is the remarkably higher weight and HSI of salivary apparatus in female which may indicate a higher amylolytic potentiality.

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ORIENTAL SPECIES OF *XORIDES* (*GONOPHONUS*) (HYMENOPTERA, ICHNEUMONIDAE)*

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A revision of the Oriental species of *Xorides (Gonophonus)* is given. *X. (Gonophonus) exquisitus* (TOSQUINET) is redescribed. A new species, *X. (G.) karnaticus* and a new subspecies, *X. (G.) exquisitus ceylonicus* are described.

Xorides (*Gonophonus*), a relatively small subgenus of the Palaearctic and Oriental distribution, is known from the Oriental Region by two species, viz. *Xorides* (*Gonophonus*) *exquisitus* (TOSQUINET, 1903) from Mont Gede (Java) and *X.* (*G.*) *carinifrons* (BALTAZAR, 1961) from the Philippines. A new species *karnaticus* is described here and *exquisitus* (TOSQUINET) is redescribed from three females of the type-series loaned by the Brussels Museum. Three subspecies of *exquisitus* are recognized here.

Subgenus **Gonophonus** FOERSTER

Gonophonus FOERSTER, 1868, *Verh. Naturh. Ver. Rheinlande*, **25** : 169. Type : *Gonophonus mokrzeckii* (KOKUJEV)=*propinquus* TSCHEK; included by KOKUJEV, 1902.

Caenostoma CAMERON, 1905, *J. Straits Br. Asiatic Soc.*, **44** : 125. Type : (*Caenostoma filicornis* CAMERON) = *exquisitus* TOSQUINET; monobasic; CAMERON, 1905, *Entomologist*, **38** : 171. Type: (*Caenostoma filicornis* CAMERON) = *exquisitus* TOSQUINET, monobasic.

Paraglypta KIEFFER, 1921, *Bull. Agr. Inst. Sci. Saigon*, **3**: 137. Type : (*Paraglypta tubigera* KIEFFER = *exquisitus* TOSQUINET; original designation.

TAXONOMY : TOWNES & TOWNES, 1960 : 501; TOWNES *et al.*, 1961 : 106; TOWNES *et al.*, 1965 : 542; TOWNES, 1969 : 212.

Face striato-punctate or rugose; malar space 0.4–0.6 x as long as the basal width of mandible, sparsely to densely punctate; flagellum 21–23 segmented, in female curved subapically, the bend involving 2–3 segments, with three peg-like bristles on their outer side; occipital carina complete above; pronotal groove smooth and shiny, sometimes with weak oblique carinae; mesoscutum moderately punctate, its median and lateral lobes often with parallel transverse carinae; notauli wide and shallow, usually smooth ; scutellum weakly convex to moderately raised, usually smooth and shiny with weak punctures; metascutellum moderately raised, with strong lateral carinae ; prepectal carina extending up to about 0.7 x the height of mesopleurum, sometimes ending at lower 0.3; metapleurum reticulate, its lower 0.3 smooth and shiny; posterior transverse carina of mesosternum complete and strong; propodeum with strong carinae, its spiracle elliptic; nervulus basad of basal vein ; intercubitus basad of second recurrent vein by as much as its length; nervellus intercepted below the middle; trochantellus of fore leg usually with an acute apical tooth on the inner side;

* The Oriental species of the subgenera *Moerophora* and *Xorides* have been treated in *Oriental Ins.*, **6** (4) : 409–417 (1972) and **8** (4) : 395 - 411 (1974) respectively.

fore and hind tibiae sometimes with a row of 4–9 spines; fore and middle femora compressed basally and tibia of female with a constriction at basal 0.3 and semicircular crease on the ventral side of the constriction; hind trochantellus in front view about 2.5x as long as its trochanter; first tergite 2.0–3.3x as long as its apical width and 1.8–2.5x the length of second, strongly narrowed at the base; second and third tergites with oblique basolateral and apical grooves; ovipositor long, strong and subcylindrical, apically decurved; ovipositor sheath 1.2–1.4x as long as fore wing and 2.6–3.3x the length of hind tibia.

The chief distinguishing features of *Gonophonus* are: (i) hind trochantellus in front view about 2.5x as long as the trochanter; (ii) posterior transverse carina of mesosternum complete and strong; (iii) subapical bend of female flagellum involving 2–3 segments; (iv) nervulus basad of basal vein; (v) intercubitus basad of second recurrent vein by not more than its own length and (vi) trochantellus of fore leg usually with an apical tooth on the inner side.

KEY TO THE ORIENTAL SPECIES OF *XORIDES* (*GONOPHONUS*)

1. Areola very long, separated from the basal area by a weak transverse carina; fore tibia without spines; frons smooth, sparsely punctate without a carina on the lateral margins; median lobe of mesoscutum with short, parallel, transverse carinae; scutellum yellow, flat or weakly convex, smooth and shiny; face transversely striato-punctuate laterally and densely punctate or longitudinally striated in the middle, yellow with a black longitudinal band in the middle; clypeus yellow, black behind the transverse crease. Java, Kalimantan, Sri Lanka, Sumatra and Vietnam..... ..... *1. exquisitus* (TOSQUINET).

Areola pentagonal, connected to the triangular basal area by a single long carina; fore tibia with a row of short spines on the inner side; frons with a longitudinal carina on its lateral margins; median lobe of mesoscutum without transverse carinae; scutellum black, strongly convex, wrinkled basally and laterally, face black, rugose, with long hairs; clypeus blackish brown..... 2

2. Occipital carina absent ventrally, complete dorsally; temple closely punctate; first and second tergites without yellow apical margins; hind coxa and femur black; basal half of hind basitarsus black; frons rugose; longitudinal carinae petiolar area of propodeum confined to the apical half. Philippines. .....*2. carinifrons* BALTAZAR.

Occipital carina complete ventrally, dorsally weak, represented by a crease; temple obliquely striated; all tergites with yellow apical margins; hind coxa yellowish-brown, femur orange; hind basitarsus entirely yellow; frons smooth with coarse punctures on the lateral margins; longitudinal carinae of petiolar area strong, extending full length. India. .....*3. karnaticus*, sp. nov.

1. Xorides (Gonophonus) exquisitus (TOSQUINET) (Figs. 2, 3, 5 & 6).

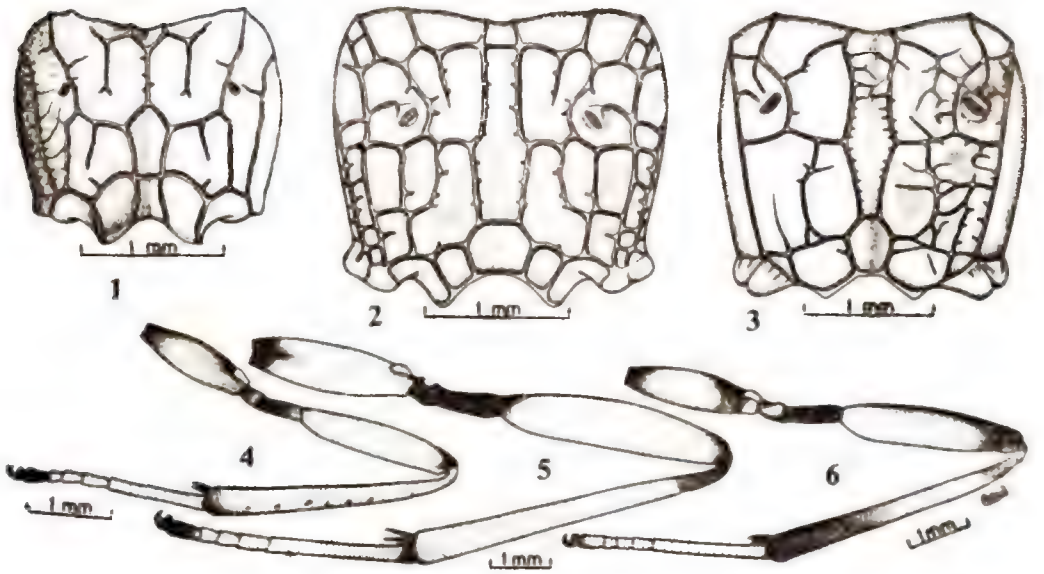
Moansa exquisitus TOSQUINET, 1903, *Mem. Soc. Ent. Belgique*, **10** : 57. Female des. Types : males, Java : Mont Tengger, 1219m (Brussels). The types are labelled "Java, Mont Gede, Aug. 1892, Fruhstorfer."

Caenostoma filicornis CAMERON, 1905, *J. Straites Br. Asiatic Soc.* **44** : 126. Male des. Lectotype male, Sarawak : Kuching (London) CAMERON, 1905, *Entomologist*, **38** : 172. Male des.

Paraglypta tubigera KIEFFER, 1921, *Bull, Agr. Inst. Sci. Saigon*, **3**: 137. Male. des. Type: Female, Vietnam: Tonkin: (Lost). Host : *Xylotrechus quadripes*; DUPORT, 1921, *Bull. Chambre d'Agr. Tonkin et Nord–Annam* 130, sup. **11** : 7. Female. des. Vietnam : Cho-Ganh. Host : *Xylotrechus qnadripes ; Chlorophorus annularis.*

Xorides filicornis : TOWNES, 1944, *Mem. Amer. Ent. Soc.*, **11** : 103. syn.

Xorides (*Gonophonus*) *exquisitus* : TOWNES & TOWNES, 1960, *Bull. U. S. Natl. Mus.*, **216** (2): 494. syn; TOWNES, TOWNES & GUPTA 1961, *Mem. Amer. Ent. Inst.*, **1** : 107. syn.



Figs. 1-3. Dorsal view of the propodeum of: 1. *Xorides* (*Gonophonus*) *karnaticus*, sp. nov.; 2. *X.* (*G.*) *exquisitus exquisitus* (TOSQUINET); 3. *X.* (*G.*) *exquisitus ceylonicus*, subsp. nov. Figs. 4–6. Colour pattern of hind leg of: 4. *Xorides* (*Gonophonus*) *karnaticus*, sp. nov.; 5. *X.* (*G.*) *exquisitus ceylonicus*, subsp. nov.; 6. *X.* (*G.*) *exquisitus exquisitus* (TOSQUINET).

Xorides (*Caenostoma*) *exquisitus* : BALTAZAR, 1961, *Monogr. Natl. Inst. Sci. Tech. Manila*, 7 : 107 syn.

This species was described from Java by TOSQUINET in 1903. Three topotype females of this species, collected and determined by J. TOSQUINET and loaned to us by Brussels Museum, were studied. In addition, one male from Sumatra, one from Kalimantan (c. w. t. of *Caenostoma filicornis* CAMERON by R. SHELFORD), three females from Sri Lanka and one female each from Malaya and Vietnam were also studied.

The distribution data of the type as recorded by TOSQUINET is, "Mont Tengger (Java Oriental), 400 pieds, 1890, H. Fruhstorfer." Three females loaned by the Brussels Museum are labelled, "Java: Mt. Gede, August 1892, Fruhstorfer", and one of them bears the label "Type". They have original determination label in TOSQUINET's hand as "*Moansa exquisitus* Tosq." These are evidently the types as has also been mentioned by TOWNES *et al.* (1961 : 107) and we believe that the type locality should be corrected to Mt. Gede as given on the label of the specimen.

Face densely punctate in the middle and finely transversely striated laterally, 0.4.–0.6x as long as wide, yellow with a black longitudinal band in the middle; malar space 0.5–0.6x the basal width of mandible; frons finely sparsely punctate with a weak, median longitudinal carina but without a carina on the lateral margins; temple smooth and shiny, weakly obliquely striated on the lower side; last flagellar segment of female 4-6x its basal width; occipital carina complete; median and lateral lobes of mesoscutum with short, parallel transverse carinae; mesoscutum also with 3–5 median longitudinal carinae behind the middle scutellum yellow, flat or very weakly convex, smooth,

sometimes with a weak median longitudinal ridge; propodeum with strong carinae, areola very long, weakly separated from the basal area; propodeal apophyses absent; fore tibia without spines; first tergite with distinct, oblique, subapical groove; second and third tergites with basolateral and subapical grooves; densely to coarsely punctate, tending to be rugose; all tergites with their apical margins yellow.

BALTAZAR (1971) recognized two subspecies of this species, viz. *Xorides* (*Caenostoma*) *exquisitus exquisitus* (TOSQUINET) and *X.* (*C.*) *exquisitus xanthopleurus* BALTAZAR. A new subspecies, *X.* (*G.*) *exquisitus ceylonicus* is described here from Sri Lanka and Vietnam.

Key to the Subspecies of *Xorides* (*Gonophonus*) *exquisitus*

1. Mesopleurum blackish–brown, with a small yellow spot behind speculum; propodeum black except a small yellow spot above the base of hind coxa; pronotum with a single large yellow spot on the upper margin; median lobe of mesoscutum entirely black; first tergite without a median yellow spot; hind tibia brownish on its apical 0.3. Java, Kalimantan, Sumatra and Malaya.....
....1. *exquisitus exquisitus* (TOSQUINET).

Mesopleurum with yellow bands or three large yellow spots; apical 0.3 of propodeum yellow; pronotum with one yellow spot each on its upper and lower margins; carinated area on median lobe of mesoscutum with a yellow spot; first tergite with a median yellow spot; hind tibia brown on its apical 0.6 or entirely yellowish–brown with a darker tinge on the extreme apex and base.....2

2. Metascutellum black; mesopleurum with two longitudinal yellow bands, upper band sometimes divided into two; second tergite with one or three median yellow spots and third tergite with a median yellow spot; hind tibia with its distal 0.6 brown; hind femur yellowish–brown, its base brownish. Philippines.....
....2. *exquisitus xanthopleurus* BALTAZAR.

Metascutellum yellow; mesopleurum with two anterior and one postero–ventral yellow spots; second and third tergites withoxt median yellow spots, only their apical margins yellow; hind tibia orange–yellow, sometimes extreme apex and base with a brownish tinge; hind femur entirely orange–yellow, sometimes brown at apex. Sri Lanka and Vietnam.....
.....3. *exquisitus ceylonicus* subsp. nov.

1. *Xorides* (*Gonophonus*)*exquisitus exquistus* (TOSQUINET) (Figs. 2 & 6) *Moansa exquisitus* TOSQUINET, 1903, *Mem. Soc. Ent. Belgique*, **10** : 57. Female. des. Types : 3 females, Java: Mt. Gede, 1219m (Brussels). *Xorides*(*Caenostoma*) *exquisitus exquisitus*: BALTAZAR, 1961, *Monogr. Natl. Inst. Sci. Tech. Manila*, **7** : 107. syn.

This subspecies can easily be distinguished from the other two by the set of characters mentioned in the key. The redescription given here is based on the specimens from Java, Malaya, Kalaimantan and Sumatra.

Female : Face about 0.5x as long as wide, densely punctate in the middle and transversely striated laterally; clypeus smooth and shiny; malar space 0.6–0.7x the basal width of mandible, finely punctate, with very weak striations near the base of mandible; temple smooth and shiny, weakly obliquely striated near the mandibular base; flagellum 21–23 segmented, first flagellar segment nearly 4.0x its apical depth, second segment about 0.9x as long as the first, last segment about 5.0x its basal width, sharply narrowed apically; frons, vertex and occiput

smooth and shiny; interocellar distance 0.75–0.86x the ocello–ocular distance; occipital carina entire; pronotum polished, with fine sparse punctures, its groove shallow and shiny; mesoscutum raised, evenly punctate, punctures fine and separated by their own diameter, median and lateral lobes with parallel transverse carinae in the middle; posterior half of mesoscutum with three parallel longitudinal carinae in the middle; notaulus wide shallow, smooth and shiny; scutellum flat, squarish, smooth and shiny: mesopleurum evenly closely punctate with long white pubescence: mesosternum with fine close punctures; metapleurum reticulate, with long white pubescence; propodeum stout, shiny with strong carinae, areola about 4.0x as long as wide near costulae, separated from the basal area by a very weak carina, apical transverse carina complete and strong, spiracle elliptic; nervulus basad of the basal vein by about 0.33x its length; hind femur 4.4–4.6x as long as its depth at middle; hind tibia 11.0–12.0x its apical depth; hind basitarsus 3.9–4.5x the length of longer hind tibial spur; first tergite 2.1–2.4x its apical width and nearly twice as long as second, strongly rugoso–punctate, less so towards the base, with deep subapical oblique grooves, cutting its apical margin into three distinct lobes; second tergite about 0.9x as long as its apical width, with deep basolateral and apical oblique grooves which enclose a raised area that is slightly depressed in the middle, densely punctate basally, moderately punctate on the convexities and towards the apex, grooves and depression striated; third tergite nearly half as long as its apical width, grooves and depression as on the second tergite but weakly represented, moderately punctate, punctures rather sparse on the raised areas; tergites 4–8 smooth and shiny; ovipositor subcylindrical, apically decurved, its sheath 212–1.3 x the length of fore wing and ..6–2·7 x the length of hind tibia.

Blackish–brown to black. Face except a median longitudinal band, apical half of clypeus, lateral margins of frons, palpi, temple except its posterior margin, scutellum, mesepimeron and apices of all tergites, yellow; antenna blackish–brown with segments 10–21 yellow, apex of the last segment black; pronotum black with a large yellow spot on the upper margin; mesoscutum and metascutellum entirely black; propleurum yellow; mesopleurum black with a small yellow spot near the speculum; propodeum black except a small yellow spot above the base of coxa; fore and middle legs yellow except their last tarsal segments and base of the tibia brownish; hind coxa brown, yellowish towards the base, trochanter brown, femur yellowish basally and brown apically, tibia brown, yellow in the middle and tarsus yellow, its last segment brown apically; all claws black; apical lobes of first tergite yellow; second and third tergites each with a yellow spot in the middle and their apical margins yellow.

Male : Similar to female in all respects except for the following characters: flagellum 38–segmented; first flagellar segment 1.2–2.0x its spical depth; second flagellar segment 2.0–3.0x as long as the first; last flagellar segment 3.0x its basal width; interocellar distance nearly equal to the ocello–ocular distance ; fore and middle tibiae without a constriction and semicircular crease at basal 0.3; first tergite 3.0x its spical width and 2.2–2.5x as long as the second which in turn is about 1.2x its apical width.

Black. Flagellum black with segments 8–12 yellow; mesopleurum with or without a yellow spot behind speculum; median yellow spots on second and third tergites tending to merge with the yellow apical margins.

Length : Female, 12.0–19.0 mm; fore wing 9.7–13.5 mm; ovipositor sheath 12.5–18.0

mm; male, 11.8–12.6 mm; fore wing 8.5–9.4 mm.

Specimens examined: 4 females, 2 males. Java: Mont Gede, 3 females (one female "Type," other two determined by J. TOSQUINET) viii. 1892, Frühstorfer Coll. (Brussels) Malaya : Kwala Kangsar (Perak), 1 female 1902, Grubauer (Vienna). Kalimantan: Kuching, 1 male, 24. v. 1903, R. SHELFORD (Oxford). Sumatra : Tandjong Morawa (Serdang), 1 male, Dr. B. HAGEN (Leiden).

Distribution : Indonesia : Java, Kalimantan and Sumatra. Malaya.

2. Xorides (Gonophonus) exquisitus xanthopleurus BALTAZAR

Xorides (*Caenostoma*) *exquisitus xanthopleurus* BALTAZAR, 1961, *Monogr. Natl. Inst. Sci. Tech. Manila*, 7 : 107. Male, female. des., fig. Type : males, Philippines: Mindanao : Lanao : Kolambugan (U. S. N. M.).

This subspecies is hitherto known only from the type locality in the Philippines. It can be readily distinguished by the set of characters mentioned in the key.

3. Xorides (Gonophonus) exquisitus ceylonicus, subsp. nov. Figs. 3 & 5

This species closely resembles *X. (G.) exquisitus xanthopleurus* BALTAZAR but can be easily distinguished from it by the following characters : Mesopleurum with two anterior and one postero – ventral yellow spots; metascutellum yellow; second and third tergites without yellow spots in the middle; hind tibia orange–yellow, rarely its extreme base and apex with brownish tinge and hind femur orange–yellow, sometimes its apex brownish.

Female : Face about 0.4 x as long as wide, transversely striato–punctate, with dense punctures and longitudinal striations in the middle; malar space 0.6 x (055–0.6)* the basal width of mandible, distinctly punctate, punctures rather sparse below the groove; flagellum 21 – segmented, first flagellar segment 4.0 x (3.5–4.5) its apical depth and nearly as long as the second, last segment 4.5 x (3.6–4.8) its basal width; frons moderately punctate, punctures very fine; vertex polished with scattered punctures; interocellar distance 1.1x (1.1-1.3) the ocello-ocular distance; punctures on pronotum fine, separated by 1.5-2.0x their diameter; scutellum smooth and shiny, finely punctate, usually with a median longitudinal ridge or carina; mesopleurum evenly closely punctate on the lower margin, rest polished with fine scattered punctures; prepectus moderately closely punctate; mesosternum moderately punctate, punctures sparse posteriorly; metapleurum reticulate, with long scattered pubescence; propodeal carina comparatively weaker, tending to merge with the reticulations; areola very long, not separated from the basal area distinctly; pleural and lateral areae irregularly reticulate, with shiny portions in their middle: hind femur 4.5 x (3.6–4.5) as long as its depth at middle and tibia 11.0x (10.5–12.5) its apical depth; hind basitarsus 5.0x (4.7–5.0) the length of longer hind tibial spur; first tergite 2.0x (1.9–2.3) its apical width and 1.8x (1.8–2.0) as long as the second, finely reticulate or rugoso–punctate in the middle, with large punctures towards the base; second tergite 0.9 x (0.85–1.0) its apical width, rugoso–punctate, moderately punctate on the apical yellow band, rather polished on the apical margin; third tergite densely punctate, striated in the depressions. its apical margin; polished; ovipositor sheath 1.3 x (1.3–1.4) the length of fore wing and 3.0 x (2.8–3.0) the length of hind tibia.

Black. Face except a longitudinal band in the middle, apical half of clypeus,

* figures in parantheses refer to the measurements of paratypes.

labrum, palpi, inner orbits, a long band on temple, segments 10-21 of flagellum, scutellum metascutellum, mesepimeron, apical 0.3 of propodeum and apical margins of all tergites, yellow; median lobe of mesoscutum with a yellow spot in the middle; upper and lower margins of pronotum with long yellow bands; propleurum with a yellow spot in the middle ; mesopleurum with two anterior and one postero – ventral yellow spots, anterior spots dorsal and ventral in position; fore and middle legs yellowish–brown, their trochanters and last tarsal segments brown; hind leg orange–yellow, coxa basally, trochanter and last tarsal segment blackish–brown, femur and tibia sometimes with brownish tinge apically ; ovipositor rust–brown, its sheath black.

Male : Unknown.

Length : Female, 10.7–17.0 mm; fore wing 8.5 – 13.0 mm; ovipositor sheath 11.0–17.5 mm.

Holotype Female, Sri Lanka, 1861, Felder (Vienna). *Paratypes*: 3 females. Sri Lanka : Kandy, 1 female, ii. 1910, E. COMBER (B. M. N. H.). PILLAI (Jaffna N. P.), 30m, 1 female, 30. xi. 1934, GAURI DUTT (F. R. I.). Vietnam : Tonkin: Hoabinh 1 female, viii. 1918, R. V. de SALVAZA (B. M. N.H.).

Distribution : Sri Lanka and Vietnam.

2. **Xorides (Gonophonus) carinifrons** BALTAZAR

Xorides (*Gonophonus*) *carinifrons* BALTAZAR, 1961, *Monogr. Natl. Inst. Sci. Tech. Manila*, 7 : 109. Female. des., fig. Type : female, Negros Oriental: Mt. Canlaon, 1097m (TOWNES).

Specimens of this species were not available for study. However, it can be easily distinguished from the other species by the characters mentioned in the key.

3. **Xorides (Gonophonus) karnaticus,** sp. nov. (Figs. 1 & 4)

This species closely resembles *carinifrons* BALTAZAR by the shape of areola and nature of propodeal carination, spines on the fore tibia, lateral carinae on frons, shape and colour of scutellum and sculpture of face. However, it deserves a separate status by having a ventrally complete occipital carina, obliquely striated temple, yellow apical bands on all tergites, colour of hind leg, sculpture of frons, and strong longitudinal carinae in the petiolar area of propodeum.

Female: Face 0.7x as long as wide, evenly strongly rugoso–punctate; clypeus closely punctate, mat; malar space 0.4x as long as the basal width of mandible, moderately closely punctate; temple obliquely striated, with few wide punctures; frons shiny, laterally with shallow dense punctures, its median longitudinal carina weak, not extending behind up to the median ocellus; frontal orbit with a distinct longitudinal carina; vertex shiny with wide sparse punctures; interocellar distance nearly twice as long as the ocello–ocular distance; occipital carina strong ventrally, dorsally weak, represented by a crease above in the middle; antenna 21–segmented, wide apically, its first and second segments equal in length, last segment about 2.8x as long as its basal width; thorax long, about 3.5x as long as wide above between tegulae; pronotum shiny with large coarse punctures; mesoscutum with fine dense punctures, rugose in the middle, notauli shallow; scutellum moderately convex, with strong lateral carinae, rugose, shiny above; mesopleurum smooth and shiny with moderately spaced punctures and long hairs on the margins; prepectal carina ending near the anterior margin ; propodeum smooth and shiny with reticulations in

pleural areae, areola pentagonal connected to the small triangular basal area by a single long carina, petiolar area with a pair of longitudinal carinae extending from its base to apex; fore tibia with a row of spines on the inner side; hind tibia 9.9x as long as its apical depth, with a row of small spines on the outer side; first three tergites densely coarsely punctate, rest smooth and shiny; first tergite 2.3x as long as its apical width and nearly twice the length of second, strongly narrowed towards the base; second tergite 0.9x as long as wide apically; ovipositor long, apically decurved, its sheath 1.4x as long as fore wing and 3.4x the length of hind tibia.

Black. Yellow portions are: flagellar segments 13–21, palpi, hind tarsus except its fifth segment and apical margins of all tergites; fore and middle legs orange, their fifth tarsal segments black; hind coxa yellowish-brown, trochanter brown, femur and tibia orange; ovipositor sheath blackish-brown.

Male : Unknown.

Length: Female, 8.0 mm; fore wing 6.2 mm; ovipositor sheath 8.7 mm.

Holotype: Female, India: Karnataka: Anmod, 762m, 27.xi. 1965, JOSEPH K. JONATHAN Coll. No. J 103 (GUPTA).
Distribution: India: Karnataka.

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NEW APHIDS (HOMOPTERA : APHIDIDAE) FROM NORTH WEST INDIA

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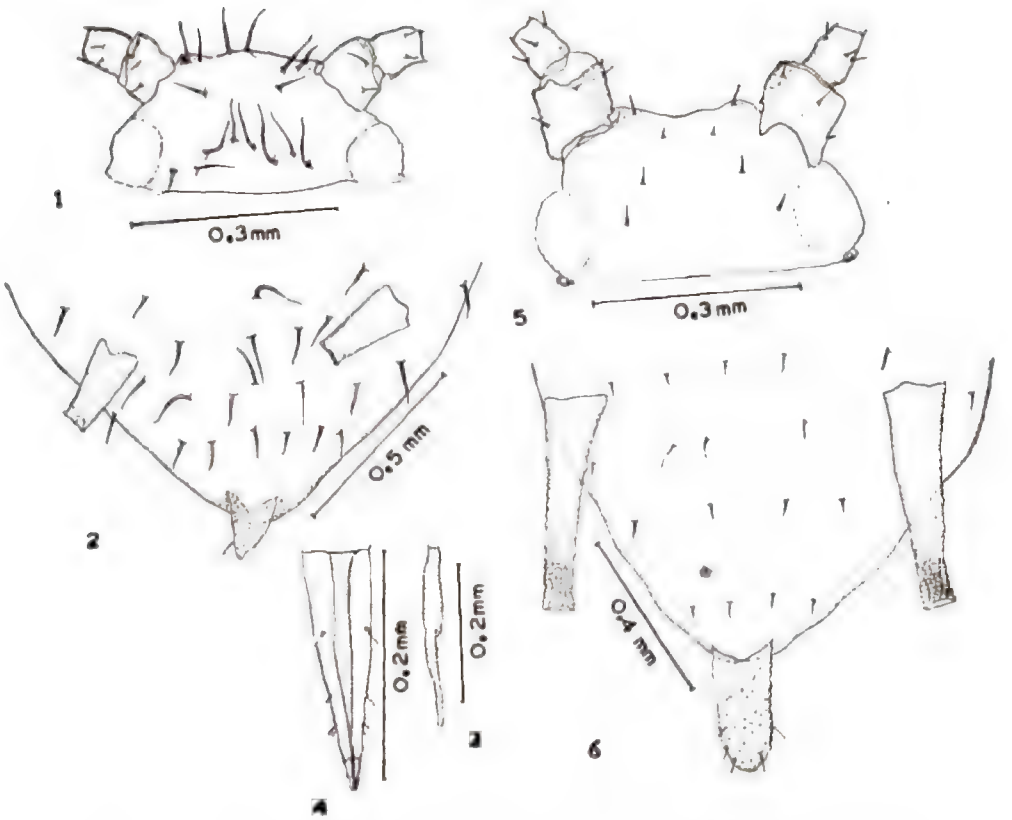
Two new species of aphids viz. *Aphis paraverbasci* and *Macrosiphum* (*Sitobion*) *pseudoalupecuri* collected from Simla Himalayas, North west India are described.

Aphis paraverbasci sp. nov.

Apterous viviparous female: Body 1.90–1.57 mm long with 1.05–1.20 mm as maximum width. Head (Fig 1) pale brown, without distinct lateral frontal tubercles but the middle of head slightly convex; dorsum smooth, with about 14–16 long flagellate hairs, longest hair on frons about 41–80 μ long and 1.77–2.75 times the basal diameter of antennal segment III. Antennae about 0.46–0.52 times the length of body: segments I and II smooth, concolourous with the head, segment I with 2 hairs and II with 3 hairs which are about 33–41 μ long; flagellum gradually imbricated from base to apex, segment VI pale brown to brown, rest of the flagellum pale; processus terminalis (Fig. 3) about 0.46–0.72 times the length of antennal segment III and 1 08–1.45 times the length of the base of segment VI; secondary rhinaria absent, but one specimen (? allatoid apterae. with 2–3 secondary rhinaria on apical 0.4 portion of the segment III; hairs on the flagellum long with flagellate apices, longest hair on segment III about 30–41 μ long and about 1.0–1.37 times the basal diameter of the segment (in the specimen having secondary rhinaria about 0.9 times). Rostrum long, reaches hind coxae; ultimate rostral segment (Fig. 4) gradually becoming narrow, about 1.93 2.2 times the length of second joint of hind tarsi, with 2 accessory hairs near the base. Thorax pale; mid–thoracic furca sessile. Abdomen (Fig. 2) pale excepting the spinal area of tergite 8 and tip of the abdomen which are brown; hairs on the dorsum stout, long with acuminate to flagellate apices anterior tergites with 8–10 hairs per segment, 7th and 8th tergites, each with 6–8 hairs, longest hair on anterior tergites about 52–90 μ long and about 1.55–3.0 times the basal diameter of antennal segment III, on 7th and 8th tergites about 67–82 μ long and about 2.0–2.62 times the mentioned diameter; tubercles on 1st abdominal segment small, on 7th segment absent or very small. Siphunculi brown, rarely dark brown, subcylindrical, slightly imbricated, with distinct flange, about 0.10–0.12 times the body and 1.5–1.69 times the cauda. Cauda dark brown, nearly triangular with about 8 hairs. Subgenital plate with 12 hairs in 2 groups on the posterior margin. Legs pale except coxae, trochanter and tarsi which are pale brown; femora and tibiae smooth, hairs on legs long and fine, longest hair on femora about 37 56 μ long, tibiae much hairy, tibial hairs are of two types; longer hairs with flagellate apices and similar in length to those on femora, shorter hairs with acute to acuminate apices, about 26–37 μ long; first tarsal segment with 3 hairs.



Figs. 1–4. *Aphis paraverbasci* new species: apterous viviparous female: 1. Head, 2. Posterior portion of abdomen, 3. antennal segment VI, 4. Ultimate rostral segment. Figs.5–6. *Macrosiphum* (*Sitobion*) *pseudoalupecuri* new species: apterous viviparous females: 5. Head, 6. Posterior portion of abdomen.

Measurements of the holotype in mm : Length of body 1.77, width 1.15; antenna 0.99; antennal segments III : IV : V : VI 0.25 : 0.17 : 0.15 : 0.12 + 0.13; ultimate rostral segment 0 .22; second joint of hind tarsus 0.11; siphunculus 0.22; cauda 0.13.

Holotype

Apterous viviparous female, India : Himachal Prodesh : Simla, Kufri, 27. xii. 1972 from a plant of family Labiatae (coll. S. CHAKRABARTHI). Paratypes: 4 apterous viviparous females and nymphs, collection data as in the holotype.

Remarks

The present new species by nature of ultimate rostral segment, siphunculi, cauda and long hairs on body comes close to *Aphis verbasci* SCHRANK (1801), but can be distinguished from the latter in having short processus terminalis in relation to antennal segment III and base of segment VI, small or absence of lateral tubercles on 7th tergite, longer hairs on the body and in having shorter siphunculus in relation to body. Having very long ultimate rostral segment, *paraverbasci*, new species also comes close to *Aphis kurosawai* TAKAHASHI (1921) and *Aphis leptorhyncha* DAVID *et al.*

(1970). But from the both species *paraverbasci* remains distinct by its short processus terminalis.

Macrosiphum (Sitobion) pseudoalupecuri sp. nov.

Apterous viviparous female. Body 2.31–2.70 mm long with 1.77–1.29 mm as maximum width. Head (Fig. 5) pale brown to brown, lateral frontal tubercles moderately developed with 1 dorsal and 1 ventral hairs on each, median frontal prominence indistinctly developed or even absent; dorsum smooth, with 4 pairs of hairs including those on lateral frontal tubercles; hairs on the dorsum of head with acuminate apices, longest hair on lateral frontal tubercles and those on the vertex about 22–38μ long and 0.65–0.8 times the basal diameter of antennal segment III. Antennae about 0.81–0.88 times the body, segments I and II concolourous with the head, nearly smooth, with 4 hairs on each, about 22–30μ long; flagellum gradually becoming brown to blackish brown from apical 0.5 portion of segment III; segment III smooth, gradually and more distinctly imbricated from base to apex; processus terminalis about equal to segment III and 2.33–4.0 times the length of base of segment VI; hairs on the flagellum with acute to acuminate apices, longest hair on segment III about 18–24μ long and 0.44–0.65 times the basal diameter of the segment; segment III with 2–5 secondary rhinaria on basal 0.4 portion. Rostrum Reaches slightly beyond mid-coxae; ultimate rostral segment segment short, about 0.65–0.74 times the second joint of hind tarsi, with 2 accessory hairs. Thorax pale. Abdomen (Fig. 6) pale, dorsum smooth; hairs stout, with acute to acuminate apices; anterior tergites with 6 hairs per segment, 7th and 8th tergites, each with 4 hairs, longest hair on anterior tergites 0.8–1.0 times the basal diameter of segment III. Siphunculi pale on basal 0.35 portion, rest gradually becoming darker apicad, subcylindrical, imbricated, reticulated on apical 0.25 portion, about 0.18–0.20 times the length of body and 1.75–2.0 times the length of cauda. Cauda pale to pale brown may be with an indistinct median constriction and with bluntish apex, with 8 hairs. Subgenital plate with 10 hairs on the posterior margin and 2 short hairs on the anterior margin. Legs pale brown to brown, femora smooth, tibiae slightly imbricated; first tarsal segments with 3 hairs.

Measurements of the holotype in mm : Length of body 2.61, width 1.21; antenna 2.26; antennal segments III : IV : V : VI 0.53 : 0.46 : 0.36 : 0.15 + 0.52; ultimate rostral segment 0.098; second joint of hind tarsus 0.131; siphunculus 0.49; cauda 0.28.

Holotype

Apterous viviparous female, India : Himachal Pradesh: Simla, 29. xii. 1972 from an unidentified grass (Graminae) (coll. S. CHAKRABARTI). **Paratypes :** 3 apterous viviparous females and nymphs, collection data as in the holotype.

Remarks

This *Macrosiphum* species is a member of the subgenus *Sitobion* in having shorter hairs on antennal segment III. A comprehensive account of Indian *Macrosiphum* spp. has been provided by DAVID (1975). The present new species comes close to *Macrosiphum* (*Sitobion*) *alupecuri* (TAKAHASHI, 1921), but can be distinguished from the latter in having 8 caudal hairs, in the proportion of siphunculi and cauda, siphunculi darker apicad and by the shape of cauda.

The type material are with the author at the present except 1 paratype of each of the above two new species, which are with Dr. D. HILLE RIS LAMBERS, The Nether lands.

Acknowledgements:– Sincere thanks are due to Dr. D. HILLE RIS LAMBERS, Bennekom, The Netherlands for the comments on the identity of the species, and to the Head, Department of Zoology, University of Kalyani for Laboratory facilities.

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NEW GENERA AND SPECIES OF TUBULIFERA (THYSANOPTERA : PHLAEOTHRIPIDAE) FROM ASSAM AND MEGHALAYA

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Two new genera *Pegothrips*, *Neodixothrips* and three new species *Pegothrips meghalaya*, *Neodixothrips assamensis*, and *Tylothrips indicus* are described. The genus *Tylothrips* is recorded for the first time from the Oriental Region and a key is provided to separate the known species.

Pegothrips gen. nov.

Head longer than wide, cheeks parallel, slightly but distinctly indented behind eyes. Eyes slightly bulged behind forming an angular projection; postoculars longer than eyes, thin and pointed almost setaceous, placed well back. Antennae 8 segmented, segment 8 slender; areola of segment 2 at extreme apex. Mouthcone short and broad; maxillary stylets mesad, wide apart. Prothorax shorter than head; anteroangulars short, anteromarginals vestigial, other prothoracic setae well developed. Praepectus absent. Forefemora strongly enlarged in both sexes; foretibiae much shorter, with an inner tubercle at apex; foretarsi armed with a strong dagger-like tooth in both sexes. Forewings broad, phlaeothripine; double fringes sparse. B_3 of segment IX of male short and exceptionally stout. All other setae thin and pointed. Tube shorter than head, anal setae shorter than tube.

Type-species: *Pegothrips meghalaya* sp. nov.

In general appearance the new genus comes close to *Arrhenothrips–Mallothrips* complex by the presence of stout forefemora in both sexes, foretibial tubercle at apex, strong dagger-like tooth in foretarsi of both sexes and absence of praepectus. While *Arrhenothrips* has a pointed mouthcone, in *Mallothrips* it is broadly rounded; but in the new genus it is shorter and much broader with maxillary stylets placed mesad and wide apart. Further, *Mallothrips* has segment 8 of antennae very short, unusually small and closely united to segment 7. Another genus in the *Arrhenothrips–Mallothrips* complex is *Scelothrips* PRIESNER also with a short broadly rounded mouthcone, head slightly angularly produced behind eyes and cheeks rough. In *Scelothrips* the forefemora are very strongly incrassate, foretibiae without tubercle but strongly pointed at apex, midlaterals vestigial, anteroangulars and anteromarginals well developed, postangulars shorter than epimerals and B_2 of IX in male weak.

However, the slight constriction of cheeks behind eyes, angular projection of eyes behind, areola of segment 2 of antennae at extreme apex, comparatively short foretibiae, lesser number of double fringes and short but exceptionally stout B_2 of segment IX of male are some unique features to distinguish it as a distinct genus.

Pegothrips meghalaya sp. nov. (Fig. 1)

Female (Macropterous): General body colour dark brown. All femora, mid and

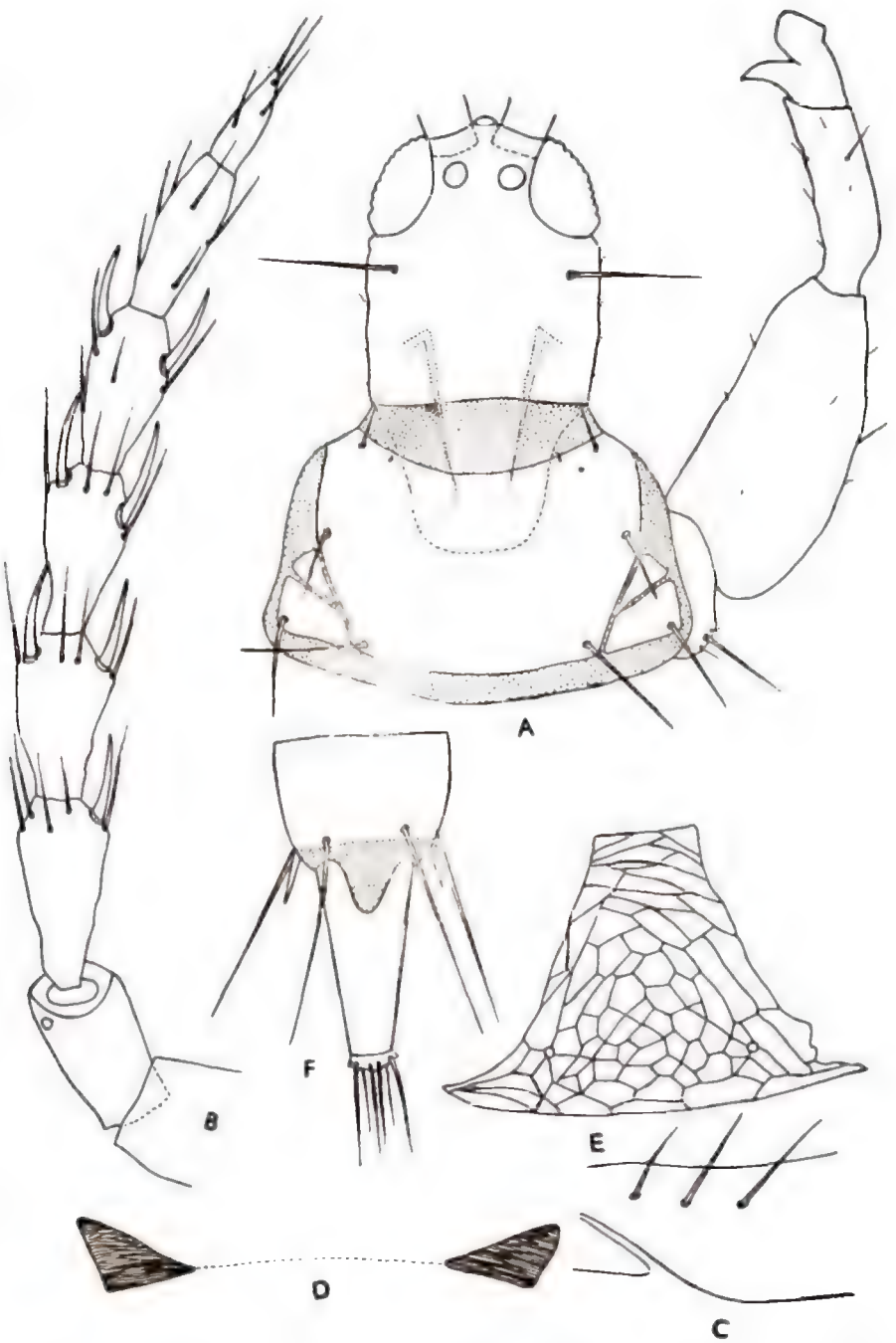

Fig. 1. *Pegothrips meghalaya* gen. et sp. nov. A. head and prothorax; B. antenna; C. basal wing bristles; D. mesopraesternum; E. pelta; F. segment IX of abdomen and tube of male.

hind tibiae dark brown; foretibiae yellow with a brownish tinge at basal half and margin, all tarsi yellow. Antennal segment 1 dark brown, 2 dark brown at basal half and margin, 3–8 yellow. Wings clear. All setae hyaline to light brown, thin and pointed.

Head longer than wide, 240*–256 long, 188 wide across eyes, 192–208 across cheeks, 188–196 across base, sides finely crenulate with 2–5 very small spines. Eyes small with slight angular projection behind, 80–84 long, 56–60 wide; all ocelli 20–24 wide, median ocellus overhanging between antennae. Postoculars thin, pointed 96–104 long, placed 24 below posterior margin of eyes. Antennal segments 3–6 subpedicellate, 4–6 symmetrical, 8 slender; segments 1–8, length (width); 52–56 (40–48); 52–60 (36); 64–72 (32–36); 52–60 (36–40); 56–64 (32–36); 56–60 (28–32); 52–56(24–28); 44–48 (12–16); sense cones moderately thick, 24–36 long. Mouthcone short and broad 104–112 long, 120–128 wide at base, 104–112 at apex; maxillary stylets retracted mesad, wide apart, 'V' shaped.

Prothorax 208 long, 240 wide at anterior margin, 380 wide at posterior. Anteroangulars short, placed away from the lateral margin, 56–60 long, anteromarginals vestigial, midlaterals 80, posteroangulars 100–120, epimerals 88–100. Epimeral suture complete. Forefemora 260–300 long, 128 wide; foretibiae 160–172 long, 60 wide with a tubercle at the apex; foretarsi with a dagger-like tooth, curved downwards, 36–40 long. Pterothorax 440–460 long, 460–480 wide across meso and 420–440 across metathorax. Forewings broad, parallel 884–918 long with 2–4 double fringes; basal wing bristles B_1–B_3 44–48, 80–84 and 80–88 long. Mesopraesternum reduced, restricted as two very small triangular sclerites.

Abdomen 432 wide at base, 420–432 at middle, 320 across segment VIII, 192–200 across segment IX. Pelta roughly triangular with apex flat. B_1–B_3 of segment IX 184–200, 168–180, 184–200 long respectively. Tube 200–208 long, anal setae 164–172 long. Total body length 2.31–2.35 mm.

Male : Macropterous : Colouration as in female.

Head 200 long, 168 wide across eyes, 172–176 across cheeks, 164–168 across base. Eyes 64–68 long, 44–48 wide; postoculars 64–72. Antennal segments 1–8, length (width) – 40–44 (36–40); 44–48 (28–32); 52–56 (28–32); 48–52 (28–36); 52–56 (32–36); 48–56 (28–32); 40–48 (24–28); 36–40 (16), sense cones 16–20 long. Mouthcone 80–88 long, 108–116 wide at base, 84–92 at apex.

Prothorax 184–196 long, 208–228 wide at anterior margin, 328–340 wide at posterior margin. Anteroangulars 24–36, anteromarginals vestigial, midlaterals 36–40, posteroangulars 78–84, epimerals 60–72 long. Forefemora 228–240 long, 108–116 wide; foretibiae 140–152 long, 52 wide; foretarsi with a dagger-like tooth 32 long, curved downwards. Pterothorax 380–400 long, 400–420 wide across meso, 380–400 across metathorax. Forewings 782–816 long, 68–84 wide, basal wing bristles 44–48, 52–60, 56–68 long.

Abdomen 372–392 wide at base, 352–360 at middle, 268–280 across segment VIII, 168–180 across segment IX; B_1 B_3 of segment IX 160 168, 36–40, 168–180 long respectively, B_2 exceptionally stout. Tube 164 long, anal setae 140 long.

Total body length 1.99 2.04 mm.

Holotype : female (Z.S.I. Reg. No. 474/H_{12}), **allotype** male (Z.S.I. No. 475/H_{12}), paratypes

*All measurements in microns unless otherwise specified.

12 females, 5 males (Z,S.I. Reg. Nos. 476–492/H_{12}), India: Meghalaya, Garo Hills, Songaak, from leaf gall of wild plant, 22.ix.75 (Dr. N. MURALEEDHARAN & Party Coll.) deposited in the National Zoological Collections of Zoological Survey of India, Calcutta.

Neodixothrips Gen. Nov.

Head as long as broad to slightly broader, constricted at base, surface strongly reticulate. Eyes large; postoculars very weak, about half the length of eyes and placed much below eyes. Antennae 8

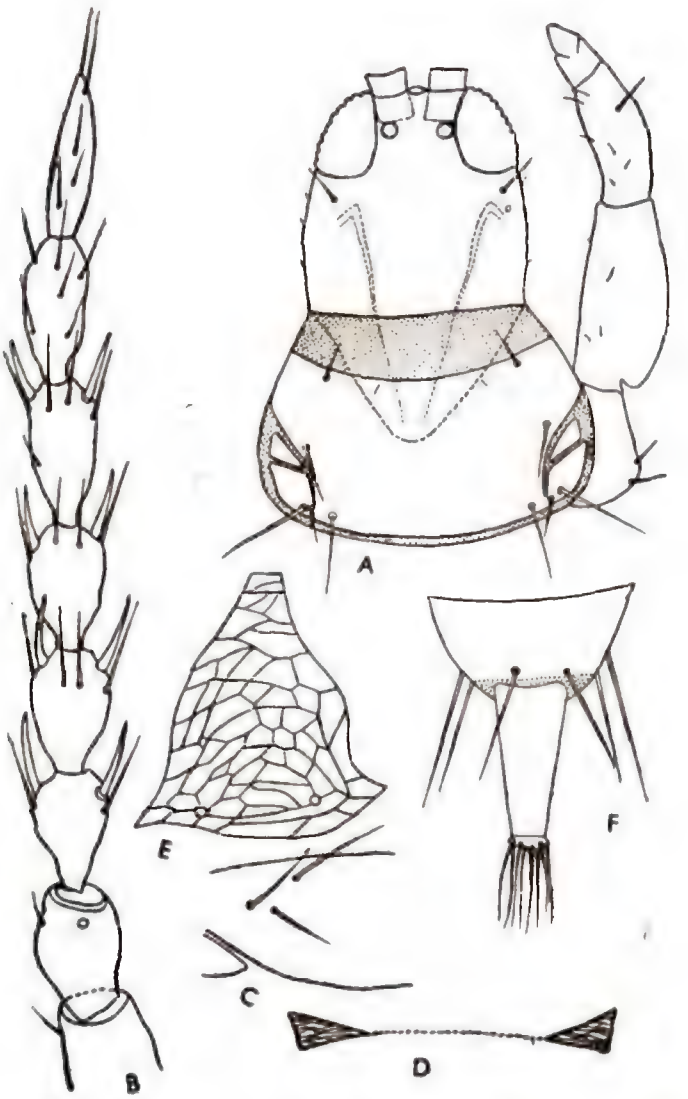

Fig. 2. *Neodixothrips assamensis* gen. et sp. nov. A. head and prothorax; B. antenna; C. basal wing bristles; D. mesopraesternum; E. pelta; F. segment IX of abdomen and tube.

segmented, 4–5 small, globular; 8 constricted at base, slender, subequal to slightly longer than 7. Maxillary stylets oculad, wide apart. Mouthcone short and broadly pointed. Prothoracic anteroangulars weak, anteromarginals vestigial, other setae moderately developed. Praepectus absent. Legs short; forefemora slightly enlarged and foretarsi unarmed in both sexes. Forewings broad, phlaeothripine: all basal wing bristles well developed, arranged not in the same line. Mesopraesternum very much reduced. Body sculptured, all setae hyaline, pointed. Tube shorter than head.

Type-species *Neodixothrips assamensis* sp. nov.

The new genus is closely allied to the monotypic genus *Dixothrips* ANANTHAKRISHNAN (1969 a, b) but it is a distinct genus and can easily be distinguished by the constriction of head at base, much shorter postoculars, shape of three terminal segments of antennae, nature of basal wing bristles and tube shorter than head.

Neodixothrips assamensis sp. nov. (Fig. 2)

Female: Macropterous: General body colour brown; head, prothorax and terminal segments of abdomen and tube darker. Antennal segment 1 brown, 2 and 8 golden yellow with brownish tinge, rest golden yellow. Forefemora yellow with brownish tinge in basal three-fourth, rest yellow, mid- and hind- femora brown; mid- and hind- tibiae brown in the basal three-fourth, rest yellow; foretibiae and all tarsi yellow. Forewings light grey. All setae hyaline and pointed.

Head about as long as broad to slightly broader 188–200 long, 168–180 wide across eyes, 192–220 across cheeks, 188–216 across base, constricted at base; cheeks smooth, convex; surface strongly reticulate. Eyes moderately large 76–84 long, 44–52 wide, all ocelli 20–24 wide, median ocellus overhanging, placed 20–24 away from paired ones, the latter 28 apart. Postoculars weak, pointed 32–40 long, placed 32–40 below posterior margin of eyes. Antennal segments 3–6 pedicellate, 4–5 globular, 8 long, slender and constricted at base, areola of 2 at extreme apex; segments 1–8, length (width): 40–48 (32–36), 48–56 (32–40), 40–44 (28–32), 40–48 (32–36), 44–52 (32–36), 48–56 (32–36), 52–56 (24–28), 56–60 (16), sense cones on 3–6 moderately thick 20–24 long. Mouthcone short, broadly pointed 96–108 long, 116–132 wide at base, 44–56 at apex; maxillary stylets retracted oculad, wide apart.

Prothorax slightly sculptured, about as long as head 188–192 long, 220–240 wide at anterior margin, 328–340 wide at posterior margin. Anteroangulars short 36 long placed away from the lateral margin, midlaterals 40–52, posteroangulars 76–80, epimerals 92-112. Forefemora 164–172 long, 84–100 wide. Pterothorax 360–400 long, 348–360 wide across meso–and 340–348 across metathorax. Forewings broad 697–731 long, 80–100 wide with 8–11 double fringes. Basal wing bristles well developed, pointed, arranged not in the same line 40–48, 48–60, 56–84 long. Mesopraesternum very much reduced, restricted to two very small triangular sclerites.

Abdomen 300–320 wide at base, 300–328 at middle, 272–280 across segment VIII, 180–188 across segment IX. Pelta roughly triangular B_1–B_3 of segment IX, 80–100, 80–112, 112–140 long respectively. Tube 140–148 long, anal setae 100–112 long. Total body length 1.77–1.82 mm.

Male : Macropterous : Colouration as in female. Head 172 long, 152 wide across eyes, 168 wide across cheeks, 160 wide across base. Eyes 72 long, 40–44 wide;

postoculars 24–32 long. Antennal segments 1–8, length (width): 40–44 (36–40), 44–46 (32–36), 40–44 (28–32), 36–40 (28–32), 40–44 (28–32), 44–48 (28–32), 48–56 (20–24), 48–56 (12–16), sense cones 20–24 long. Mouthcone 88–100 long, 120 wide at base, 72–80 at apex.

Prothorax 160–172 long, 180 wide at anterior margin, 280 at posterior margin. Anteroangulars 20–28 long, anteromarginals vestigial, midlaterals 40–44, posteroangulars 20–28, epimerals 60–76. Forefemora 140–152 long, 72–84 wide. Pterothorax 360 long, 320 wide at meso and 308 at metathorax. Forewings 646–663 long, 64–88 wide with 4–7 double fringes; basal wing bristles 40–44, 44–52, 55–64 long.

Abdomen 268–272 wide at base, 260 at middle, 206 across segment VIII, 128 across segment IX. B_1–B_3 of segment IX, 56–88, 48–56, 120–140 long respectively. Tube 128–132 long, anal setae 100 long. Total body length 1.36–1.65 mm.

Holotype

Female (Z. S. I. Reg. No. 403/H_{12}), **paratypes** 5 females, 1 male (Z.S.I. Reg. No. 495–500/H_{12}) India : Assam, Cachar District, Loharband 3-x-75 from tubular leaf galls (Dr. N. MURALEEDHARAN and party Coll.) and **allotype** male (Z.S I. Reg. No. 494/H_{12}), **paratypes** 5 females, 3 males (Z. S. I. Reg. No. 501–508/H_{12}) same locality as holotype, 4.x.75, from leaf galls of wild plant, deposited in the National Zoological Collections of Zoological Survey of India, Calcutta.

Genus **Tylothrips** HOOD

Tylothrips HOOD, 1937, *Revta. Ent. Rie de* J., 7 (4), 494.

Tylothrips PRIESNER, 1949, *Bull. Soc. Found I Ent.*, **33**, 89, 91.

The collection of a new species of *Tylothrips* HOOD a rare genus from Meghalaya is an interesting and valuable addition to Indian Tubulifera. HOOD (1937) described the new genus and species *T. concolor* from Peru and subsequently (1955) he described *T. bruesi* from Florida. Unfortunately both the species are based on a single specimen each and the availability of more material of *T. indicus* nov species undoubtedly adds considerably to a better understanding of the genus *Tylothrips*. It is worthy to note that the two hitherto known species are reported to bc mycophagous forms whereas the present species has been taken from wild plants.

KEY TO THE SPECIES OF *TYLOTHRIPS* HOOD

1. Head 1.2 times as long as wide across eyes, terminal segments of antennae forming a club-segment 3 of antennae shorter than 4, all tibiae tuberculate along inner margin..... ..... *concolor* HOOD.
   Head much longer (1 : 4–1.5), terminal segments of antennae not forming club, segment 3 of antennae subequal to longer than 4, only foretibiae tuberculate along inner margin .. 2.
2. Segment 6 of antennae longer than 7 and 8, postoculars shorter than eyes, anteroangulars, well developed, basal wing bristles asymmetri, cally disposed, body setae blunt to very little dilated at tip..... *bruesi* HOOD.
   Segment 6 of antennae shorter than 7 and 8, postoculars longer than eyes, anteroangulars wanting, basal wing bristles symmetrically disposed, body setae expanded at tip..... ..... *indicus* sp. nov.

Tylothrips indicus sp. nov. (Fig. 3)

Female: Macropterous : General body colour inclusive of antennae and legs dark brown with a blackish shade along the outer margin of antennae, cheeks and legs. Forewings grey with a median streak. All setae dark brown, lighter at tip, long, stout and knobbed at tip.

Head a little produced in front of eyes, with a notch behind eyes, about 1.3 times longer than wide across cheeks 248–280

Fig. 3. *Tylothrips indicus* sp. nov. Female; A. head and prothorax; B. antenna; C. basal wing bristles; D. mesopraesternum; E. pelta; F. segment IX of abdomen and tube.

long, 172–180 wide across eyes, 200 across cheeks, 192–196 across base, cheeks warty with 3 moderately strong spines, sides convex, converging at base, surface strongly reticulate. Eyes bulged, one third the length of head, 76–80 long, 48–56 wide; all ocelli 20–24 wide, median ocellus on elevation, placed 20 away from the paired ones, the lateral 20–24 wide. Postoculars 1.5 times longer than eyes, stout expanded at tip 120–136 long, placed 34–38 below the posterior margin of eyes. Antennae very long, 2.5 times longer than head, segment 3–6 pedicellate, 7 subpedicellate, almost rectangular, 8 constricted at base; terminal segments not forming a club, pedicel of 3

crenulate; segments 1–8 length (width) : 52–60 (44–48); 60–64 (32–36); 100–108 (32 – 36); 96 – 104 (36 – 40); 88 – 96 (28–32); 64–76 (28–32); 84–92 (24–28); 76–84 (24–28); sense cones on 3 to 7 40–52 long. Mouthcone very short and broad 80–92 long, 120–132 wide at base, 72–80 at apex; maxillary stylets retracted mesad, wide apart.

Prothorax about 0.7 the length of head, 140–180 long, 234–240 wide at anterior margin, 300–340 at posterior margin. Anteroangulars wanting, anteromarginals very weak 16–20 long, midlaterals 123–136, posteroangulars 140–148, epimerals 140–156; all setae arise from cone–like tuberculate projection, the cone of epimerals more prominent. Praepectus absent, probasisternum well developed. Forefemora very slightly enlarged, inner margin straight with minute tubercles 200–220 long, 30–38 wide; foretibiae armed with 10–11 prominent teeth like tubercles bearing setae along inner margin, foretarsi with a prominent incurved tooth 20 long. Pterothorax 460–529 long, 420–500 wide across meso– and 400–520 across metathorax. Forewings broad at base, narrow beyond middle 1.037–1.105 mm long, 88 wide at base, 60 at middle and 28–40 at apex; basal wing bristles, arranged in the same line, long. stout and expanded at tip 38–100, 116–120, 96–100 long respectively; double fringes absent. Mesopraesternum complete, very well developed with a median crest.

Abdomen 460–500 wide at base, 440–560 at middle, 288–320 across segment VIII, 180–196 across segment IX. Pelta roughly triangular with apex flat. B_1–B_3 of segment IX knobbed 160–168, 160–176, 164–172 long respectively. Tube 200 long, anal setae short, 100–120 long. Total body length 2.5–2.7 mm.

Male : Macropterous : Colouration as in female, Head 228 long, 160 wide across eyes, 168 across checks. 152 across base. Eyes 80 long, 44–48 wide; postoculars 104–112 long. Antennal segments 1–8 length (width) : 52 (40), 56 (32), 92 (28), 96 (28), 88 (28), 68 (24), 72 (24); 76 (24); sense cones 48–55 long. Mouthcone 80 long, 116 broad at base, 80 at apex.

Prothorax 136 long, 180 wide at anterior margin, 260 at posterior margin. Anteroangulars wanting, anteromarginals very weak 20 long, midlaterals 112, posteroangulars 104–112, epimerals 120–128. Forefemora 300 long, 80 wide, foretibiae armed with teeth–like tubercles along inner margin, foretarsi provided with a tooth 24 long. Pterothorax 400 long, 355 wide across meso– and 360 across metathorax. Forewings 918 long, 76 wide at base, 56 at middle and 48 at apex, basal wing bristles 80, 72–80 long respectively.

Abdomen 364 wide at base, 300 at middle, 216 across segment VIII, 132 across segment IX. B_1–B_3 of segment IX–136–140, 44–48, 160 long respectiely. Tube 160 long, anal setae 100 long. Total body length 1.94 mm.

Holotype female (Z. S. I. Reg. No. 509/H_{12}), **allotype** male (Z. S. I. Reg. No. 510/H_{19}), paratypes 2 females (Z. S. I. Reg. Nos. 511–512/H_{12}), India: Meghalaya. Shillong. Mawphlang, 6.ix.75, from wild plant Dr. N, MURALEEDHARAN & party Coll.), deposited in the National Zoological Collections of the Zooligical Survey of India, Calcutta.

The new species comes close to *T. bruesi* HOOD by the nature of the terminal segments of antennae and presence of tubercles only in the foretibiae. It, however, differs from *T. bruesi* HOOD by longer postoculars, absence of anteroangulars, symmetrical disposition of basal wing bristles and the nature of the major body setae.

Acknowledgements:– We thank Dr. S. KHERA, Joint Director-in-Charge, for providing necessary facilities to work; Dr. O.B. CHHOTANI, and Dr. S.K. TANDON, Superintending Zoologists and to Shri K. RAI, and Dr.B. DUTTA, Zoologists for their help and encouragement and Prof. T. N. ANANTHAKRISHNAN, Entomology Research Unit, Loyola College Madras for kindly confirming the identity of new taxa, going through the manuscript and for offering valuable suggestions.

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Entomon, 1976, *Vol.* **1**, *No. 2, pp.* 185 *to* 188.

NOTE ON TWO LITTLE KNOWN SPECIES OF *ANTROCEPHALUS* KIRBY (HYMENOPTERA : CHALCIDIDAE) FROM INDIA

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Two little known species of *Antrocephalus* KIRBY viz. *A. dividens* (WALKER) and *A. renalis* WATERSTON are redescribed with a correction of the generic status of the former species. A new synonym of *A. renalis* is reported.

The paper contains redescriptions of two oriental species of *Antrocephalus* KIRBY collected from different places in South India. The earlier descriptions of these two species are vague and without sufficient illustrations, making it rather difficult to establish their precise identity. Hence this account. A mistaken generic identification of *A. dividens* (WALKER) is corrected and this species has been recorded for the first time from India. A new synonym of *A. renalis* WATERSTON is reported.

1. Antrocephalus dividens (WALKER) comb. nova. (Figs. 1–7)

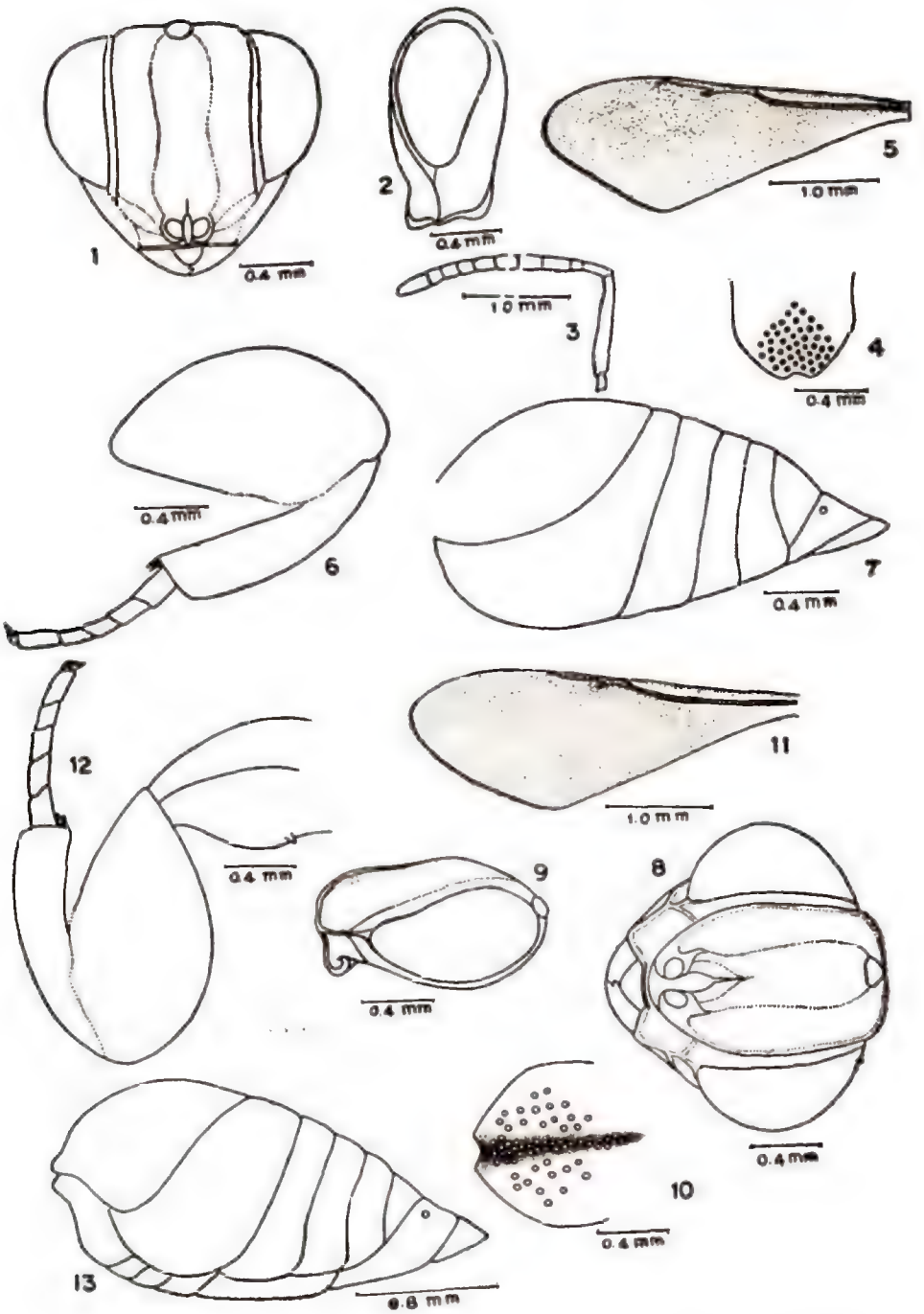
Chalcis dividens (WALKER) 1860, *Ann. Mag. Nat. Hist.*, **6** : 357. *Brachymeria dividens* (WALKER) : MANI, 1938, *Cat. Ind. Ins.*, **3** : 54.

Female : Length 5.3 mm. Head black, eyes pale yellowish-black; antenna black; thorax black, shiny; tegulae reddish-black; wings hyaline, veins brown; all legs except the black fore coxa, ferrugenous-red; abdomen black; shiny. Pubescence yellowishwhite.

Head (Figs. 1 & 2) : width a little more than the width of thorax, surface distinctly pitted. Median ocellus a trifle larger than the lateral; the distance between median and lateral ocelli about half the interocellar distance; interocular space a little over one and three-fourths interocellar distance; width of ocellar area a little more than four-fifths as wide as interocular space; interocellar distance a little over three times the maximum diameter of the lateral ocelli. Antenna (Fig. 3) slender; scape not quite reaching the front ocellus.

Thorax : With rounded pits on dorsal side; interspaces of pits shiny, as wide as or half as wide as the diameter of the pits on scutellum and mesoscutum; on the pronotum the interspaces narrow and rugose; anterior carinae on pronotum distinct, bituberculate, scutellum a little less than one and one fifth as long as wide; apical margin as in figure 4. Fore wing and its veins are as in figure 5. Hind coxa on ventral side densely punctate and pubescent, dorso-outer side smooth and shiny without a distinct tooth near base; hind femur (Fig. 6) with minute pits and moderate pubescence on outer side, inner side with less pits and less pubescence and without an inner basal tooth.

Abdomen (Fig. 7) about as long as the combined length of pronotum, mesoscutum, scutellum and propodeum; first tergite



Figs. 1–7. *A. dividens* (WALK.), female : 1. head; 2. head lateral aspect; 3. antenna; 4. scutellum dorsal aspect; 5. forewing; 6. hindfemur; 7. abdomen lateral aspect.
Figs. 8–13. *A. renalis* WATERSTON, female : 8. head; 9. head lateral aspect; 10. scutellum dorsal aspect; 11. forewing; 12. hindfemur; 13. abdomen lateral aspect.

smooth and shiny, base with short carina on each side of the median fovea (as long as the fovea); second tergite with faint pits and sparse pubescence.

Male : Length 4.7 mm. Colour of the legs slightly different from female; coxae black with apices of mid and of hind coxae reddish; fore and mid femora and their tibiae almost black with their apices reddish; hind femur and tibia ferrugenous red as in female. Abdomen distinctly shorter than the combined length of pronotum, mesoscutem, scutellum and propodeum together.

Specimens examined

1 female (Plesiotype) coll. No. 2551 on pin, India : Calicut., Coll. T. C. NARENDRAN on 6-xi-1969. 1 female coll. No. 2566 on pin, India : Calicut, coll. T. C. NARENDRAN on 28-3-1970. 1 male coll. No. 2559 collection data same as for 2551.

Distribution

This species had been originally recorded from Sri Lanka (Ceylon). The present author records this species for the first time from India.

Remarks

This species *A. dividens* was first described by WALKER (1860) and he wrongly included the species under the genus *Chalcis* of authors (not of FABRICIUS). Later this species continued to be known wrongly as *Brachymeria dividens* (WALKER) when GAHAN & FAGAN (1923) synonymised the genus *Chalcis* of authors (not of FABRICIUS) with the genus *Brachymeria* WESTWOOD.

2. Antrocephalus renalis WATERSTON
(Figs. 8–13)

Antrocephalus renalis WATERST. 1922, *Ind. For. Rec.*, **9** : 69 *Stomatoceras sulcatiscutellum*, GIRAULT, 1971, *Descr. Chal. var. Cum.* 5 : 9 Syn. nov. (Type present in U. S. National Museum, Washington D.C. Locality : India : Coimbatore).

Female : Length 5.0 mm. Head black; eyes brownish black; antenna reddish black; thorax black; shiny; tegulae brownish black. Wings almost hyaline; veins of fore wings brown with the submarginal pale. Legs black. Abdomen black, shiny. Pubescence yellowish white.

Head (Figs. 8 & 9) : Width a little more than the width of thorax, surface rather shallowly pitted with a line of deeper pits along the inner margin of compound eyes. Median ocellus a little larger than the lateral; the distance between median and lateral ocelli about half the interocellar distance; interocular space a trifle over two and one fifth times the interocellar distance; width of ocellar area a little over four-fifths as wide as interocular space; interocellar distance two and one fourth times as wide as the maximum diameter of the lateral ocelli. Antennae somewhat stout; scape reaching the front ocellus, length subequal to the combined length of segments two to six; pedicel as long as segment four, almost twice as long as wide; ring segment as long as wide; fourth segment a little shorter than twice the length of ring segment, one and two-thirds as long as wide: fifth segment slightly shorter and slightly wider than fourth segment; sixth segment a little shorter and a little wider than fifth segment (rest of the segments are found missing from the antennae).

Thorax : with rather small pits on dorsal side; interspaces of pits shiny and in most places of scutellum and mesoscutum as wide as or wider than the diameter of pits; pronotum with distinct anterior carinae at sides, turning faint near the middle, not forming tubercles; scutellum about one and one-fifth times as long as

wide and as in figure 10. Fore wing and its veins are as in figure 11. Hind coxa a little less than three-fourths the length of hind femur, ventral side minutely and densely punctate with pubescence, dorso-outer side smooth and shiny with a tooth near base; hind femur (Fig. 12) outer and inner sides moderately pitted and moderately pubescent, interspaces between the pits rugose; inner side with a distinct basal tooth.

Abdomen (Fig. 13) : Longer than the combined length of pronotum, mesoscutum, scutellum and propodeum together; first tergite smooth and shiny with the base having short but distinct carina on each side of the median fovea (as long as the fovea); second tergite with pubescent pits on sides; sixth tergite rugulose and with shallow pits.

Plesiotype

1 female coll. No. C. U. 2582 on pin, India: Andhra, Coll. P. SANJIV RAO on 12-i-1969.

Distribution : Sri Lanka and India.

Host : *Nephantis serinopa* M. (Lep., Xyloryctidae)

Remarks : A specimen identified by Dr. B. D. BURKS (U. S. National Museum, Washington D.C., U.S.A.) as *Antrocephalus sulcatiscutellum* (GIRAULT) is present in the Department of Zoology, University of Calicut. Dr. BURKS identified this specimen after comparing the type specimen of *Stomatoceras sulcatiscutellum* (GIRAULT) present in the U.S. National Museum. When the present author compared this specimen with the plesiotype of *Antrocephalus renalis* WATERSTON, he is convinced that the species *sulcatiscutellum* is a new synonym of *Antrocephalus renalis* WATERSTON.

Acknowledgements:– I am grateful to Dr. Z. BOUCEK, Commonwealth Institute of Entomology, C/o. British Museum (Natural History), London, for determining the specimens of *Antrocephalus dividens* (WALKER) and *Antrocephalus renalis* WATERSTON and for other useful information on these species. Thanks are also due to Dr. K. J. JOSEPH, Head of the Department of Zoology, University of Calicut, for his keen interest in this work and for providing necessary facilities.

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Entomon, 1976, *Vol.* 1, *No.* 2, *pp.* 189 *to* 191.

BRIEF COMMUNICATIONS

A NEW SPECIES OF *CHRYSOPA* (NEUROPTERA : CHRYSOPIDAE) FROM INDIA

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(*Received 4 October 1976*)

Chrysopa (Chrysoperla) punensis **sp. nov. (Neuroptera : Chrysopidae) is described from Maharashtra, India.**

In the course of studying the material collected from Poona, Maharashtra, the author has encountered a new species which is described below. The type specimens will in due course be deposited in the Zoological Survey of India, Calcutta.

Chrysopa (Chrysoperla) punensis sp. nov.

Male : Head : Greenish yellow, genae reddish brown, clypeus yellow with brown borders; frons yellow but with a reddish brown stripe on each side; vertex greenish yellow; palpi brown. Antennae yellow and the segments provided with white and brown setae.

Thorax : Pronotum : Green with median yellowish vitta which continues the rest of the thorax; broader than long with anterior angles rounded; a prominent ridge in the middle; with sparse covering of short and pale hairs. Meso and Metanotum : Green with some yellowish interruptions and pale hairs. Legs : Greenish but tarsi yellow and claws brown with teeth at the bases ; femora with white hairs but tibiae with black hairs and spines. Wings (Figs. 1 & 2) : Narrow, subacute at the tip; membrane hyaline, absence of any spot ; pterostigma greenish; all the veins and crossveins entirely green.

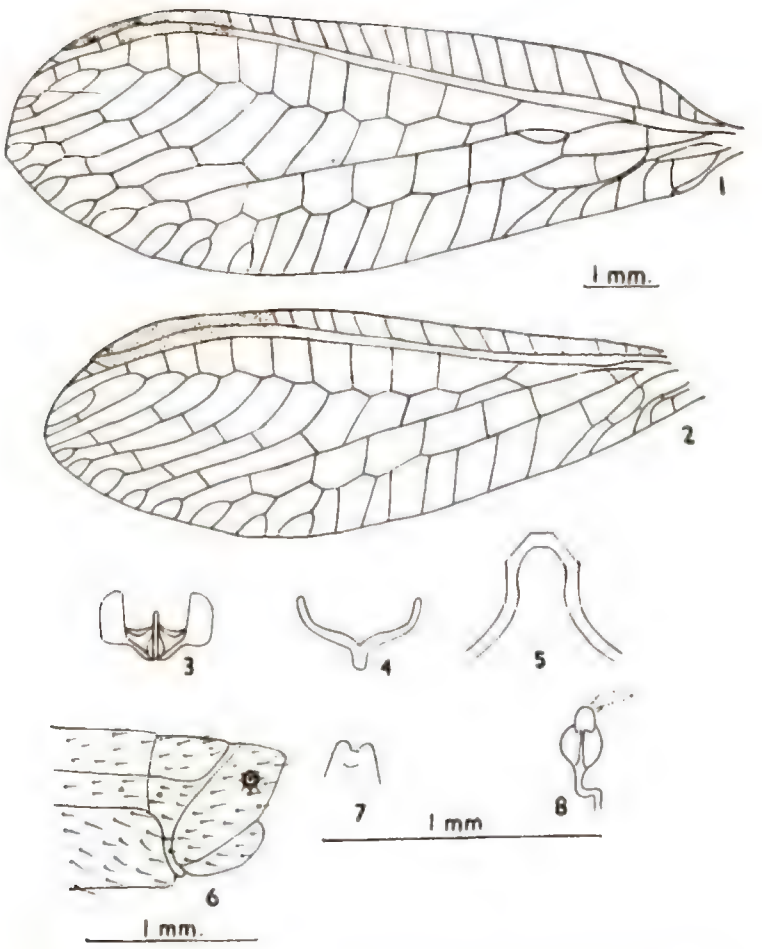
Forewing: 22 costal crossveins before pterostigma; first cubital cell shorter than the second cubital cell; tip of the intramedian cell ends before 1st radio-medial crossvein; 5 branches of radial sector going to the posterior margin; number of gradates in left forewing 5/6 and in right 5/7. Hindwings : same as in forewing but 16 costal crossveins before the pterostigma; number of gradates in left hindwing 5/7 and in right hindwing 4/6.

Abdomen (Figs. 3–5) : Greenish with white hairs; sternite 8+9 elongated with rounded tip as in figure 5; tignum narrow, its acumen broad with rounded apex; gonarcus narrow with large, flattened side pieces; entoprocessus acute, arises from the lateral piece and extends upto the arcessus ; arcessus long and straight.

Female: Abdomen (Figs. 6–8 of paratype) : Tergite 9 and ectoproct an elongated structure with rather acute upper angle; gonapophysis lateralis not very broad; subgenital large in ventral view with prominent well separated apical lobes and broadly rounded; spermatheca with high vella.

Ecological observation: The species was captured from the vegetable fields with seasonal crops close to the Bhama river. The crops were highly infested with aphids and thysanopterans.

Holotype male: India : Maharashtra : Khed, near Bhama river, Pune, 3. vii. 76, Coll. S. K. GHOSH.



Figs . 1–8 : *Chrysopa (Chrysoperla) punensis* sp. nov. Holotype male : 1. Forewing; 2. Hindwing; 3. Gonarcus with arcessus, entoprocessus; 4. Tignum; 5. Tip of sternite 8+9; Paratype female ; 6. Apex of the abdomen; 7. Subgenital plate; 8. Spermatheca.

Allotype female and paratypes 8 females : collection data same as for the holotype.

Remark : The new species belongs to the carnea group, in having slender arcessus, small entoprocessus and also the tip of the intramedian cell not extending beyond the 1st radio-medial crossvein. But it differs from *Chrysopa carnea* STEPH. (cf. TJEDER, 1936; KILLINGTON, 1937) by the presence of short hairs on the wing margins and veins, whitish hairs on the femora and by the shape of the genitalia and from *Chrysopa* (*Chrysoperla*) *gujaratensis* GHOSH by the shape of the genitalia.

Acknowledgements:- The author is indebted to Dr S. KHERA, Joint Director-in-Charge, Zoological Survey of India, Calcutta, for the facilities given to him to work on Neuroptera and to Dr. B. K. TIKADER, Deputy Director, Zoological Survey of India, Western Regional Station, Poona for extending help in various ways.

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Entomon, 1976, *Vol.* 1, *No.* 2, *pp.* 193 *to* 194.

INHIBITION OF VITELLOGENESIS BY ALLATECTOMY IN THE RED COTTON BUG, *DYSDERCUS CINGULATUS* FABR. (INSECTA, HETEROPTERA, PYRRHOCORIDAE)

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(Received 5 September 1976)

Allatectomy in 24 36 Hr old *Dysdercus cingulatus* females resulted in complete inhibition of vitellogenesis.

It was reported that extirpation of pars intercerebralis neurosecretory cells (NSC) in the red cotton bug *Dysdercus cingulatus* inhibited vitellogenesis partially (JALAJA *et al.*, 1973). Inhibition was found to be complete when extirpation was carried out between 0–3 Hrs after emergence (JALAJA, 1974). Inhibition of vitellogenesis caused by extirpation of NSC could be reversed by implantation of fresh NSC (JALAJA, 1974). So it was proposed to find out if allatectomy had any inhibitory influence on vitellogenesis in this animal, as corpus allatum is widely known to stimulate vetellogenesis in most insects (ENGELMANN, 1970).

Animals used for this study were taken from the stock colony maintained in the laboratory. Females 24–36 Hrs after adult emergence were used for the experiments. The animals were anesthetised in ether and affixed to Petri-dish by plasticine, head bent down exposing the neck membrane. A puncture on this membrane showed the translucent corpus allatum just behind the brain attached to the ventral wall of the anterior end of the aorta. The allatum was removed by fine sterile tweezers causing as little damage to the aorta as possible. A few crystals of a mixture of antibiotics, Penicillin-Streptomycin, containing phenylthiourea for prevention of tanning, were applied to the wound, and head was released which automatically closed the wound. Sealing of the wound was not necessary. Sham-operated animals were kept as controls. A few normal males were also kept along with both sets of females to allow mating. The animals were fed on cotton seeds and reared in glass chimneys. Controls and experimentals, at least ten each, were sacrificed on days 3, 5 and 7 after the operation. The ovaries were dissected out in insect Ringer, fixed in BOUIN'S fluid and processed in the routine way. Sections were stained in HEIDENHAIN'S iron haematoxylin eosin. Success of allatectomy was confirmed by dissection and the data from those animals whose allata were not completely removed, was discarded.

It was found that as in the normal animals (JALAJA & PRABHU, 1971, 1976), in the control animals also he abdomen started swelling on the third day. But in those animals in which allatectomy was complete, the abdomen did not swell, an indication that vitellogenesis did not take place in them. None of these animals laid eggs till 7 days unlike controls all of which laid eggs by this time. Histological studies showed that in the control animals vitellogenesis already started on day 3 and eggs were laid on or before day 7. However in none of

the experimental animals in which allatectomy was complete yolk granules were seen till day 7. Oocytes also started resorbing.

It may be seen from this that the corpus allatum is necessary for vitellogensis in *Dysdercus cingulatus*. Earlier observations revealed that NSC were essential for vitellogenesis in this animal (JALAJA, 1974). So it appears that both NSC and corpus allatum are essential for normal vitellogenesis in this animal. However, it is possible that only one of these endocrine centres is directly involved, and this centre is controlled by the other centre which exerts only a trophic function as in many insects (ENGELMANN, 1970). Unpubiished observations (JALAJA, 1975) show that this is indeed the case.

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Entomon, 1976, *Vol.* 1, *No.* 2, *pp.* 195 *to* 197

ON *ODONTELLA* (*CLAVONTELLA*) *MACRONYCHIA* (PRABHOO) – A SOIL COLLEMBOLA FROM KERALA

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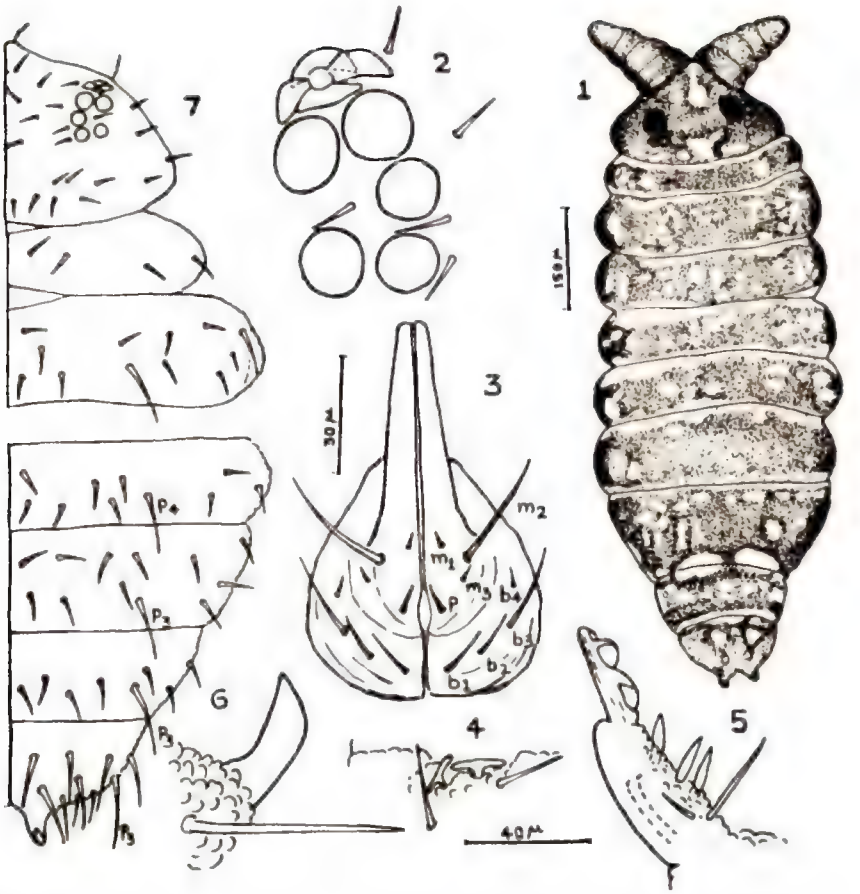
The subspecies *Odontella trispina macronychia* (PRABHOO) 1971 has been elevated to the species rank and named *Odontella* (*Clavontella*) *macronychia* based on the study of additional material. A complete redescription of the species is given.

In an earlier communication (PRABHOO 1971) the author described the subspecies *Odontella trispina macronychia* based on a single specimen collected from a tea field in the Ponmudi hills. The subspecies was created for the characteristically large anal spines different from those of *Odontella trispina* (SALMON). The description was however incomplete as the details of the chaetotaxy and buccal cone could not be studied from a rather ill preserved specimen. Subsequently a few examples of *Odontella* were collected from Kallar (Ponmudi hills) and Madathara lying at the foot of the Western ghats. Examination of these individuals suggested that they were identical to the form described earlier from Ponmudi and that these examples constituted a species which was distinct but closely related to the Malayasian and Nepalese species of *Odontella*. A complete redescription of the species, which has become necessary, is given below.

Odontella (Clavontella) macronychia (PRABHOO) 1971 (Figs. 1–7) Syn: *Odontella trispina macronychia* PRABHOO 1971, p. 13.

Length up to 1 mm. Sky blue pigment distributed irregularly on the body and on the appendages except for the distal part of the furcula. Intersegmental areas more or less clear. Ventral side lighter. Background colour yellowish. Integument coarsely granulated all over. Antennae slightly shorter than head. Segments related as 13 : 13 : 12 : 15. Ant. IV apically without retractile papillae but with 4 subapical sense rods on the outer side and 1 rod on the inner side, which are fairly well differentiated; ventrally there are numerous peg-like setae. Ant. III/IV with two 'T' shaped sense rods close to each other. Ocelli 5+5. Postantennal organ with four peripheral lobes and a central area. Buccal cone pointed and with the seta m_2 very long, m_1 and m_3 almost vestigial; basal area with four setae of which b_1 and b_2 are subequal, b_3 is longest and b_4 is shortest. Tibiotarsi without tenent hair. Claws with a pair of small basal lateral teeth and a prominent median tooth. Unguiculus absent. Ventral tube with 3 + 3 setae. Tenaculum with 3 + 3 dents on rami. Furcula short. Dens and mucro related as 8 : 5. Manubrium with 4 + 4 setae dorsally. Dens with 3 spines and 2 unequal setae. Mucro apically rounded with two large lamellae and a small basal lobe. Anal spines well developed, a little over half as much as the hind claw. Body chaetotaxy similar to that of *O. nepalica* YOSII. The setae are smooth and sensory setae not



Figs. 1–7. *Odontella* (*Clavontella*) *macronychia* (PRABHOO) paratype. 1. Dorsal view; 2. Postantennal organ and ocelli; 3. Buccal cone, ventral view; 4. 'T' shaped sense rods of ant. III IV; 5. Dens and mucro; 6. Anal spine; 7. Dorsal chaetotaxy of head, th. I II and abd. III VI, diagrammatic. Figs. 2, 4, 5 and 6 are drawn to the same scale.

much differentiated. Abdominal segments with not more than two rows of setae. On abd. V the two rows of setae are not well separated from each other. The setae a_5 on abd. IV and a_8 and p_4 on abd. V have been found to be fluctuating.

This species is closely related to *O. nepalica* YOSII (1971) and *O. trispina* (SALMON) 1951, but the latter two species have only small inconspicuous anal spines. Extensive sampling of the tea fields and frequent examination of soil and litter samples from the forests revealed that this species showed a preference to forest soils than to tea soils although the latter also had a fairly good accumulation of organic matter.

Holotype : 1 example on slide, tea field of Merchiston estate, Ponmudi, 750 m, 13.v.1962.

Paratypes : 4 examples, forest, Madathara, 250 m, 22.ix.1974; 4 examples forest, Kallar (Ponmudi hills), 300 m, 25.iii.1975.

Acknowledgements:– I am thankful to Prof. K. M. ALEXANDER for facilities provided in the department.

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ANASTATOIDEA BRACHARTONAE GAHAN, A NEW PUPAL PARASITE OF *NEPHANTIS SERINOPA* MEYRICK

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(*Received 4 August 1976*)

A pupal parasite *Anastatoidea brachartonae* (Hymenoptera : Chalcidoidea) has been recorded for the first time from *Nephantis serinopa* MEYRICK the black-headed caterpillar pest of coconut in Kerala.

Anastatoidea brachartonae GAHAN

Nephantis serinopa MEYRICK, the black-headed caterpillar pest of coconut in Kerala is parasitised by about a dozen parasites. This is the first record of *Anastatoidea brachartonae* GAHAN (Fig. 1) from the pupae of *N. serinopa* collected from Kayamkulam (India) during 1970.

Fig. 1. *Anastatoidea brachartonae* GAHAN

A. brachartonae was first described by GAHAN (1927) from Java as a primary and secondary parasite of *Brachartona catoxantha* HAMPSON. As a primary parasite, it is found to be ectoparasitic upon the prepupal larvae or the pupae of *Brachartona*. As a secondary parasite it has been collected from the puparia of *Degeeria albiceps* MACQUART, *Ptychomyia remota* ALDRICH and from cocoons of *Apanteles* species.

The diagnostic features of the parasite are as follows: Colour blackish; pedicel slightly bluish; face below antennae coppery mixed with purplish; a narrow strip along the eye margin metallic green; the concave posterior portion of mesoscutum marked with bluish green and coppery; mesopleura with green and purple tincts in some lights, prosternum metallic green; hind margin of hind tibiae from near base to apex narrowly margined with white.

Face shagreened and clothed with short scale-like hairs and the cheeks with moderately long black bristles. Scrobe distinctly but not deeply impressed, eyes large and distinctly hairy; lateral ocelli touching the eye-margins; vertex rather narrow and clothed with black bristles; wings hyaline

and bare at base; hind legs long, their femora compressed but not expanded, their tibiae with two unequal spurs, hind basitarsus about as a long as the four following joints together, compressed into a flange behind, the flange about equal in width to the non-compressed portion; abdomen about as long as thorax, the first to third tergites more or less distinctly emarginate medially; ovipositor exerted a little more than the length of abdomen.

The percentage of parasitism seems to be very low as so far only a single parasite could be obtained out of some 2200 host pupae collected from Kerala.

Material examined :

1 female Coll. No. 1960. India : Kerala : Kayamkulam from *Nephantis serinopa* M. on 1970. This specimen is deposited in British Museum (Natural History) London.

Acknowledgements:- Thanks are due to Dr. Z. BOUCEK, Commonwealth Institute of Entomology, C/o. British Museum (Natural History), London, for establishing the identity of the species and to the United States Department of Agriculture for financial assistance under P. L. 480 (Grant No. FG-IN-327).

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Entomon, 1976, *Vol.* 1, *No.* 2, *pp.* 201 *to* 202.

A NEW SPECIES OF PREDATORY ROVE BEETLE FROM INDIA (COLEOPTERA : STAPHILINIDAE)*

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and

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(Received 27 August 1976)

A new species, *Hypocyptus ricini*, predatory on tetranychid mites on castor is described.

In India, the genus *Hypocyptus* MANNERH. is represented by only one species *H. marginalis* CAMERON from Chakrata district. This has also been recorded from Europe, America, Africa, Pakistan and Ceylon. Until now these have been reported from dead bark, fallen leaves, vegetables, debris etc. The second species herein described as new is predatory on tetranychid mites.

Hypocyptus ricini sp. nov. (Fig. 1)

Yellowish black, shining species with finely grey pubescence; head, thorax and elytra yellow; antennae and legs reddish testaceous, the femora a little darker. Head, thorax and elytra practically uniformly punctate. Antennae smaller than head and thorax together, three to seven joints shorter than first and second both, eight-ten forming a club and all glabular in shape, tenth much longer as compared to eight and nine. Thorax fully twice as broad as long, the posterior angles rounded, very finely obsoletely, moderately and closely punctured. Elytra broader and about one half longer than the thorax, sculpture like that on thorax. Abdomen bordered, quite broad, no visible ground sculpture. Wings without apparently visible veins, very heavily fringed at the posterior border and also completely covered with fine hairs. Length 4 mm.

Holotype : Female on slide, on castor leaves along with tetranychid mites, Delhi I.A.R.I. 10-x-1969 TILAK RAM.

Paratype : 2 females, on tag mounted and one on slide bearing the same data. Types in National Pusa Collection, I. A. R. I., New Delhi-110012.

This species is most closely related to *H. gracilicornis* CAMERON from which it is distinguished by its colouration, size, antennae and punctation of the pronotum and elytra.

Acknowledgement:- The authors express their deep sense of gratitude to the late Dr. S. PRADHAN, the then Head of the Division of Entomology for all the necessary facilities and encouragement.

* This forms part of the M.Sc. (Ento.) dissertation of the senior author.

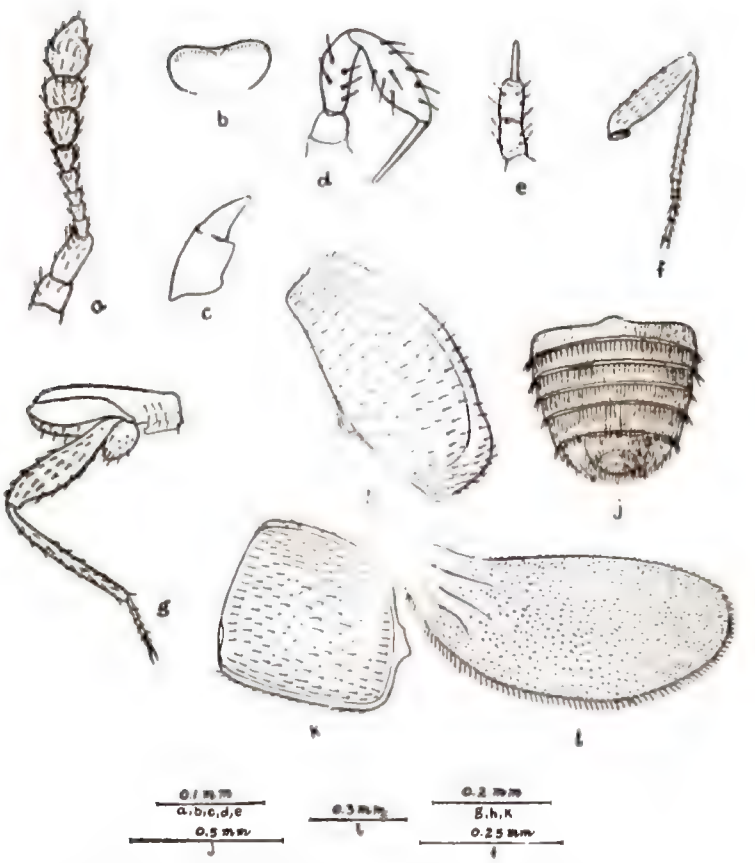

Fig. 1. *Hypocyptus ricini*, sp. nov., a. antenna; b. labrum; c. mandible; d. maxillary palp; e. labial palp; f. foreleg; g. hindleg; h. pronotum; j. portion of abdomen; k. elytra; l. hindwing.

Entomon, 1976, *Vol.* **1**, *No.* 2, *pp.* 203 *to* 205.

NEW COMBINATIONS OF SOME TYPHLOCYBINES (HOMOPTERA, CICADELLIDAE, TYPHLOCYBINAE) FROM INDIA

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(*Received 16 August 1976*)

Nine species of typhlocybines are transferred to the genera other than to which they were reported earlier. ***Erythroneura cassiae*** **AHMED is transferred to the genus** ***Cassianeura*** **RAMAKRISHNAN & MENON,** ***Zygina equata*** **SINGH and** ***Z. simplices*** **SINGH to** ***Empoascanara*** **DISTANT,** ***Pruthius erythromaculatus*** **RAMAKRISHNAN & MENON and** ***P. varians*** **RAMAKRISHNAN & MENON to** ***Limassolla*** **DLABOLA,** ***Hardiana thaiosimilis*** **RAMAKRISHNAN & MENON to** ***Thaia*** **GHAURI, and** ***Zygina manaliensis*** **SINGH,** ***Z. pakistanica*** **AHMED and** ***Z. serrata*** **SINGH to** ***Zyginidia*** **HAUPT.**

Surveys of north – western India were conducted during 1966–75 for the collection of leaf–hoppers from different kinds of vegetation. Thirty seven species of typhlocybines belonging to 23 genera were found from this collection. Out of these, 9 species are transferred to the genera other than to which they were reported earlier.

The proposed new combinations are:

1. **Cassianeura cassiae** (AHMED), comb. n.

Erythroneura cassiae (AHMED), 1970a, *Pakist. J. Zool.* **2** (1) : 34–35.

Erythroneura cassiae AHMED; SOHI & KAPOOR, 1973 a, *Entomologist's Rec. J. Var.* **85** : 217–218.

Cassianeura sexmaculata RAMAKRISHNAN & MENON, 1973, *Oriental Ins.* 7 (1) : 27–29, Syn. n.

Erythroneura cassiae was described by AHMED (1970a) from Lyallpur (Pakistan) on Indian laburnum (*Cassia fistula* LINN.). He reported that the aedeagus was without processes. However, SOHI & KAPOOR (1973a) collected this species from the same host plant at Ludhiana (Punjab) and reported the presence of one pair of apical processes on the aedeagus. A new genus, *Cassianeura* taking *Cassianeura sexmaculata* RAMAKRISHNAN & MENON as its type species was described by RAMAKRISHNAN & MENON (1973) from the same host plant at Delhi. On the basis of similarity in male genitalia, *Cassianeura sexmaculata* is considered to be a synonym of *Cassianeura cassiae*.

This species was collected from Haryana, Himachal Pradesh, Jammu & Kashmir, Punjab and Uttar Pradesh from different plant species, viz. *Atniaris* sp., Bishop wood (*Bischofia javanica* BLUME), Indian persimmon (*Diospyros peregrina* (GAERTN.) GURKE), Jack–fruit, *Artocarpus integrifolius* AUTH.), Kassod–tree (*Cassia siamea* LAMK.), *Kuchla* (*Storychmas noxvomica* LINN.), Mysore–fig (*Ficus drupacea* THUNB. var. *pubescens* (ROTH.) CORNER), *papri* (*Holoptelea integrifolia* (ROXB.) PLANCH.), Pilkhan (*Ficus lacor* BUCH.–HAM.), pride of India (*Lagerstroemia thorelli* GAGNEP.), white *siris* (*Albizzia lebbeck* (LINN.) BENTH.), Spanish–cherry (*Mimusops*

elengi LINN.), *Sterculia acerifolia* CUNN. and summer cypress (*Kochia scoparia*) (LINN.) SCHRAD. var. *culta* FARWELL).

2. Empoascanara equata (SINGH), comb. n. *Zygina equata* SINGH, 1969, *Res. Bull. Punjab Univ. Sci.* **20** (3-4) : 344-345.

SINGH (1969) described *Zygina equata* from grasses at Simla (Himachal Pradesh). According to the structure and setosity of male plate, this species belonged to the genus *Empoascanara* DISTANT to which it has been transferred. It has been reported from the Punjab on black-gram, cowpeas, Egyptian clover, ground-nut, jhonkra (*Fagonia cretica* LINN.) linseed, lucerne and sunnhemp (BINDRA *et al.* 1973). In addition to above plant species, it was also collected from musk-melon, spinach and sweet potato.

3. Empoascanara simplices (SINGH), comb. n.

Zygina simplices SINGH, 1969, *Res. Bull. Punjab. Univ. Sci.* **20** (3-4) : 342-343.

Zygina simplices was described by SINGH (1969) from grasses at Kulu and Chandigarh. According to the structure and setosity of male plate, this species belongs to the genus *Empoascanara* DISTANT. Earlier, this species was reported from Bilaspur (Himachal Pradesh) on Malabar-nut (*Adhatoda vasica* NEES) (BINDRA *et al.*, 1973). Author collected it from groundnut at Ludhiana (Punjab).

4. Limassolla erythromaculata (RAMAKRISHNAN & MENON), comb. n. *Pruthius erythromoculatus* RAMAKRISHNAN & MENON, 1972, *Oriental Ins.* **6** (1) : 121-122.

Pruthius with *Pruthius aureatus* as its type species was described by MAHMOOD (1967) from Singapore. DWORAKOWSKA (1969) synonymised *Pruthius* MAHMOOD witn *Limassolla* DLABOLA. Hence, *Pruthius erythromaculatus* RAMAKRISHNAN & MENON is transferred to the genus *Limassolla*. It was reported from Kulu (Himachal Pradesh) on *Artemisia scoparia* WALDST. & KIT. (SOHI & KAPOOR, 1973b).

5. Limassolla varians (RAMAKRISHNAN & MENON), comb. n. *Pruthius varians* RAMAKRISHNAN & MENON, 1972, *Oriental Ins.* **6**(1) : 122-123.

Since the genus, *Pruthius* MAHMOOD has been synonymised with *Limassolla* DLABOLA (DWORAKOWSKA, 1969), the new combination *Limassolla varians* (RAMAKRISHNAN & MENON) is proposed for *Pruthius varians* RAMAKRISHNAN & MENON).

6. Thaia thaiosimilis (RAMKRISHNAN & MENON), comb. n. *Hardiana thaiosimilis* (RAMAKRISHNAN & MENON, 1974, *Oriental Ins.* **8**(4) : 441-443.

Hardiana thaiosimilis was described from Karnataka state by RAMARISHNAN & MENON, (1974) on grasses. Since, DWORAKOWSKA (1970) has synonymised *Hardiana* MAHMOOD with *Thaia* GHAURI, the species *thaiosimilis* of the genus *Hardiana* MAHMOOD is transferred to the genus *Thaia* GHAURI.

7. **Zyginidia manaliensis** (SINGH), comb. n. *Zygina manaliensis* SINGH, 1969 *Res. Bull. Punjab Univ. Sci.* **20** (3-4) : 341-342.

Zygina manaliensis was described from grasses at Manali (Himachal Pradesh) by SINGH (1969). The grasses were : *Aristida adscensionis* LINN., *Cynodon dactylon* (LINN.) PERS., *Sorghum halepense* (LINN.) PERS. and *Dicanthium annulatum* (FORSK.) STAPF which were growing intermingled. This species possesses paired aedeagal atrial processes, aedeagal shaft compressed laterally and scaly sculpture near the gonopore. By these characters it comes to *Zyginidia* HAUPT to which it is transferred. It was reported from arcachne (*Acrachne racemosa* (HEYNE), OHWI annual spear grass (*Poa annua* (LINN.), barley, Bermuda grass, black-gram, crab

grass (*Digitaria sanguinalis* (LINN.) BEAUV.), finger-millet, goose-grass (*Erechites valerianifolia* D. C.), Italian-millet, Johnson grass, lucerne, maize, oats, pearl-millet, red-pepper, sandbur *Cenchrus catharticus* LINN.), seed bird grass (*Phalaris minor* RATZ.), sorghum, sunnhemp, Sudan grass, wild oats and wheat (BINDRA *et al.* 1973; BRAR, 1974).

In addition to above plants this species was also collected from brinjal, *Citronella* sp., common millet, Napier-bajra hybrid, rice, sugar cane and sweet potato.

8. **Zyginidia pakistanica** (AHMED), comb. n. *Zygina pakistanica* AHMED, 1969. *Pakist. J. Zool.* **1** (2) : 172–174.

Zygina pakistanica was described from *Zizyphus jujuba* MILL. by AHMED at Rawalpindi (Pakistan). This species is transferred to the genus *Zyginidia* HAUPT as it possesses paired aedeagal atrial processes. It was collected from the same plant species at Ludhiana (Punjab) which constitutes a new distribution record of this species from India.

9. **Zyginidia serrata** (SINGH), comb. n. *Zygina serrata* (SINGH), 1969, *Res. Bull. Punjab. Univ. Sci.* **20** (3–4): 339–340.

Zygina serrata from grasses was described by SINGH (1969) at Simla (Himachal Pradesh). On the basis of the presence of paired aedeagal atrial processes, the new combination *Zyginidia serrata* (SINGH) is proposed for *Zygina serrata* SINGH. Earlier, it was reported from Egyptian clover, grasses and musk-melon (SINGH, 1969; BINDRA *et al.*, 1973). The additional plants which harboured this species included black-gram and groundnut.

Acknowledgements: The author is grateful to Dr. O. S. BINDRA (the then Head of the Department of Entomology) and Dr. A. S. SIDHU, Head of the Department of Entomology for the facilities provided. Thanks are also due to Dr. V. PRASAD and Dr. V. C. KAPOOR for going through the manuscript critically.

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Entomon, 1976, *Vol.* 1, *No.* 2, *pp.* 207 *to* 208.

XV INTERNATIONAL CONGRESS OF ENTOMOLOGY, WASHINGTON D. C., AUGUST 19–27, 1976

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(*Received 26 November 1976*)

The Fifteenth International Congress of Entomology was held from 19–27 August 1976 at Washington Hilton Hotel, U. S. A. The Conference was attended by over 2000 delegates from all over the world. There were over 1500 overseas delegates representing most of the countries.

The scientific program included the opening and closing plenary sessions, several Congress Symposia and Sectional meetings which ran simultaneously and covered almost all the aspects of Entomology. A few major symposia were presented each morning during the Congress with no conflicting meetings scheduled. Special symposia arranged by the Sections to invited speakers were held in the afternoons. Informal conferences on certain interesting subjects such as Chemosterilization, Stored-Product Acarology, Stored–Product Insect Population Ecology, Pathogens on Stored–Products Insects, Insect Growth Regulators etc. were also organised. The various aspects covered included Systematics, Genetic Control of Insects, Physiology and Biochemistry, Ecology, Toxicology, Behaviour, Forest Entomology, Stored Product Insects, Agricultural Entomology and Pest Management, Pesticide Development, Management and Regulation, Social Insects and Agriculture, Medical and Veterinary Entomology, Insecticide Resistance, Insect Impacts on the Quality of Forest and Urban Environments and Tropical Stored–Product Entomology. A large number of papers on Morphology, Systematics, Physiology, Toxicology, Stored Product Entomology, Pesticide Resistance, Pheromones, Allomones and Kairomones, Insect Control inclucing Genetic Control of Insects etc. were presented and discussed.

The informal conference on Chemosterilization was held at Agricultural Environmental Quality Institute, Beltsville which was attended by about 50 delegates from different countries. Each member of the panel of experts presented his views with regard to the status and prospects of chemosterilants which was followed by a panel discussion.

A proposal for a Conference on a global strategy for use and regulation of pesticides was discussed in an informal meeting of delegates organised by the Chairman of Planning Committee U. S. Environmental Protection Agency.

The Permanent International Committee on the Working Conference on Stored–Product Entomology also met under the Chairmanship of Dr. ROBERT DAVIS and decided Kenya as the next venue of the Conference to be held in 1978.

Certain other academic organisations also found it possible to meet during the Congress at Washington D. C.

The opening address of the Congress was delivered by Prof. T. R. E. SOUTHWOOD, Imperial College of Science and Technology, London on *Ecology and Mankind.* He emphasized the role played by ecology in the activities of mankind. The closing address was delivered by Prof. THOMAS R. ODHIAMBO, International Centre of Insect Physiology and Ecology, Kenya on *Entomology and the Problems of Tropical World.*

The papers in Symposia and Sectional meetings mainly centered round the current problems of the world and their possible solutions based on the most recent thinking and modern tools and techniques in hand.

Sight-seeing and pre- and post- conference tours to other areas of USA were arranged.

The Cangress ended after declaring Japan the venue for the XVI International Congress of Entomology to be held in 1980.

Entomon, 1976, *Vol.* 1, *No.* 2, *pp.* 209

BOOK REVIEW

ATLAS OF AN INSECT BRAIN by NICHOLAS J. STRAUSFELD. pp. i–xiv & 214, 71 plates (some in colours) and 81 figures, 1976, Springer-Verlag, Berlin Heidelberg, New York, size – 33.5 cm x 25 cm.

This highly technical, profusely illustrated, almost inimitable volume, aptly entitled *Atlas of an Insect Brain*, attempts to unravel the complexities of the principal neuropile regions of the insect brain as typified by that of the common housefly, and in view of the arthropod neuropile forming an excellent basis for the study of related phenomena about the computation that neurons can do, such detailed explorative studies on the shapes and disposition of the single neuron within the brain, sufficiently project the architectural patterns comprising the most complicated form of neuronal arborisation.

The work comprises seven chapters of which two, *viz.* Chapters 6 and 7 relating to the Atlas proper (involving sections through the brain), followed by the form and disposition of the neurons cover more than half the volume. One is struck by the presentation of the three-dimensional lattice work of the associating neuropiles in the central body and the suggestion that the disposition of its elements is reminiscent of the thalamus-reticulate formation of vertebrates. In order to clearly follow these structural details the first five chapters serve as a guide with the historical aspects of neuroanatomy in the first chapter, followed by the second, presenting information on the ramifications of the insect neuron; the main division of the brain are outlined in Chapter 3, according to their affiliation with the visual, chemosensory and mechanosensory inputs, while chapter 4 provides the descriptive anatomy of the brain of *Musca*, giving comparisons with the same brain regions of other insects; the numerical data presented in Chapter 5 on the quantitative aspects of the fly brain, such as the total number of neurons in the brain, their distribution in the various regions, the volume of the brain, density of neurons, the number of receptor neurons received by the brain as well as those connected with the ommatidia and ocelli, appear to be revealing pieces of information.

Of the two appendices, appendix I seeks to provide extremely useful information to students of neuroanatomy through providing detailed procedures of the histological techniques for a variety of methods which could be employed in the study of diverse insect groups. What has been most revealing is the inclusion of unparalleled colour photographs depicting the results which may be obtained through utilisation of these techniques. Appendix II deals with the glossary of technical terms, a must in such a grossly technical work and certainly fulfils the need of every student of neuroanatomy.

The 28 large size plates depicting sections of the brain at various levels, with as many figures indicating portions enlarged, not to mention the coloured plates, both photographs as well as colour washed diagrams, leaves an unusual experience to the reader, who will not only wonder at the complex architecture of the so profoundly complex, yet tiny brain of the housefly, but also feel a sense of reverential awe for the author whose mastermind enabled such a work possible.

Students of neuroanatomy of animals in general and insect physiology will find in this unique volume, a treasure house of knowledge which will lead them to unravel the further mysteries of the brains of insects.

T. N. ANANTHAKRISHNAN

NEWS *

A symposium on *Insects and Environment* will be held in the Department of Zoology, University of Delhi, Delhi 110007 from 21–23 February 1977, under the auspices of the Centre of Advanced Study in Zoology, and will cover : i. Distribution and abundance of insects in relation to environment; ii. Physiological basis of insect environment relationships; iii. Insecticides and environmental pollution. The symposium is being convened by Professor K. N. SAXENA, Head of the Dept. of Zoology, University of Delhi.

The *Second Symposium on Oriental Entomology* will be held in Madras from March 18–22, 1977. The sessions would include i. Biotaxonomy, Ecology and Biogeography; ii. Physiology and Ethology; iii. Cytology and Genetics; iv. Agricultural Entomology; v. Medical and Veterinary Entomology and vi. Toxicology. The Convener of the symposium is Dr. T. N. ANANTHAKRISHNAN, Director, Entomology Research Unit, Loyola College, Madras 600034.

Dr. N. C. PANT, Head of the Division of Entomology, Indian Agricultural Research Institute, New Delhi has been appointed Director of Commonwealth Institute of Entomology, London. He has been a Founder Member of the *Association for Advancement of Entomology* and of the Editorial Board of *Entomon*, and is also Vice President of the Association.

Dr. T. N. ANANTHAKRISHNAN, Director, Entomology Research Unit, Loyola College, Madras has been elected Fellow of the Indian National Science Academy. He has been a Founder Member of the *Association for Advancement of Entomology* and is the Editor-in-Chief of *Entomon*.

* Contributions to *News* column of the journal are welcome, and should be sent to the Managing Editor.

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Articles should be neatly type written double spaced, including References, Legend, Tables etc., on one side only of good quality bond paper, leaving sufficient margin. The first page should give the title of the article (when the title contains the name of species, give its higher taxa in brackets), name and full address of the author(s) and a short title. The second page should contain only the abstract which should outline the findings and conclusions without any reference to the text, tables or illustration; it should also be as concise and informative as possible.

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Books : NAYAR, K. K. (1973) *Elements in Insect Endocrinology*, Prentice Hall, India, 56pp.
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